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CATALOGUE
OF THE
MONTANA STATE
SCHOOL OF MINES

BUTTE, MONTANA
1908-1909

MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

NINTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1908-1909

WITH ANNOUNCEMENTS FOR THE YEAR
1909-1910

CALENDAR FOR 1909-1910.

1909

August 27 and 28, Entrance and Special Examinations.
August 30, First Semester begins.
October 29, Close of First Term, First Semester.
November 1, Second Term, First Semester begins.
November 25, 26, 27, 28, Thanksgiving Vacation.
December 18, End of First Semester.

1910

January 3, Second Semester begins.
February 22, Washington's Birthday.
March 11, close of First Term, Second Semester.
March 14, Second Term, Second Semester begins.
May 27, Commencement Day.
May 31 to July 10, Mine Surveying, Sophomores.
July 18 to August 27, Field Work in Geology, Juniors.
July 18 to August 27, Field Work in Surveying, Freshmen.
August 29, First Semester begins.

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CALENDAR

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BOARDS OF CONTROL.

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Members Ex-Officio.

EDWIN NORRIS, Governor of the State,
President of the Board.

W. E. HARMON, Superintendent of Public Instruction,
Secretary of the Board.

ALBERT J. GALEN, Attorney General.

Term Expires 1911

E. O. BUSENBURG,	Lewistown
N. W. McCONNELL,	Helena

Term Expires 1910

JOHN M. EVANS,	Missoula
C. R. LEONARD,	Butte

Term Expires 1909

G. T. PAUL,	Dillon
C. N. KESSLER,	Helena

COMMITTEE ON SCHOOL OF MINES

E. O. BUSENBURG,
G. T. PAUL,
C. R. LEONARD.

BOARD OF TRUSTEES.

Term Expires 1912

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<i>President and Treasurer of the Board.</i>	
CHARLES MATTISON,	Butte
A. H. WETHEY,	Butte

Term Expires 1909

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C. W. GOODALE,	Butte

H. C. HOPKINS,
Secretary of the Board.

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President and Professor of Mechanics.

GEORGE W. CRAVEN, B. S.,
Professor of Mathematics and Drawing.

THEODORE SIMONS, E. M., C. E.,
Professor of Mining and Ore Dressing.

FRANCIS CHURCH LINCOLN, S. B., E. M., A. M.,
Professor of Geology and Mineralogy.

ALEX. GILFILLAN, B. S., C. E.,
Professor of Metallurgy and Chemistry.

LESTER J. HARTZELL, E. M.,
Assistant Professor of Chemistry.

JOHN B. CLAYBERG, L. L. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Instructor in Surveying and Drawing.

GEORGE W. KNEISLY, B. S., A. M.,
Instructor in Geology and Mineralogy.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It was a significant date, and it marks the first national provision for education in the interest of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statemanship that dictated these two systems of education as the best means to secure the best interests of the entire people.

The first Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight other members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The Legislative Assembly of the State of Montana passed an act early in the year 1895 providing for the establishment of a State School of Mines. This act provided for a Board of Trustees to be chosen by the State Board of Education. To the Board of Trustees is committed the immediate supervision of the School of Mines; the adoption of a course of study and the election of officers and members of the faculty; but all of the acts of this body are subject to the approval of the State Board of Education. The Trustees hold office for a term of four years. This act of the State Legislature also provided for the location of the School of Mines at Butte, the mining center of the State.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the campus overlooks the city, mines, and smelters, as well as the

mountains which form the continental divide and which surround the valley on the east and south.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the school. The building was erected during the years of 1896 and 1897 through the use of funds advanced by the citizens of Butte, who were repaid in full when the bonds were finally issued in 1900. The bonds issued amount to \$120,000, bearing five per cent interest, and maturing in thirty years, but payable in fifteen years at the option of the State. These bonds are secured by the land endowment of the School.

The Legislative Assembly of 1907 appropriated \$59,000 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed during the summer of 1908.

The buildings of the State School of Mines are of red brick, with stone foundations and trimmings. The main building is three stories above the basement; it faces toward the east, overlooking the city. The length along the front is one hundred and eighteen feet and the depth ninety-four feet. The building contains 37,000 feet of available floor space and is almost entirely of fire proof construction.

The basement of the building is used by the Chemical and Metallurgical departments and the Mechanical testing laboratory. The first floor is given to the offices and to lecture rooms and the laboratory of the Department of Physics. On the second floor are the offices and lecture rooms of the departments of Mining and Geology, the Mineralog-

ical laboratory, and the Library. The third floor is used for the freshman and sophomore drawing rooms and for the thin section room. Several store rooms and a well-equipped dark room for photographic work are also on this floor.

The Metallurgical building is just west of the main building, the two being connected by a tunnel from the basement of the main building. The new building is one hundred and ten feet by seventy-two feet. A portion in which are the boilers and engine room is two stories high, while that portion containing the ore dressing and metallurgical laboratory is one room with available height of thirty-four feet. The laboratory is equipped with the apparatus to make tests on lots of ore in quantities ranging from one to ten tons.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1909, was \$30,480 per year.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The School is, therefore, wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind. Those who complete this course will receive the degree of Engineer of Mines.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes must pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for work done in other institutions of recognized rank, pro-

vided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which he comes.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted without examination or certificate to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

LIST OF ACCREDITED HIGH SCHOOLS IN THE STATE OF
MONTANA.

City High Schools.

Anaconda	Fort Benton
Billings	Great Falls
Butte	Hamilton
Columbus	Helena
Forsyth	Virginia City

County High Schools.

Beaverhead, Dillon	Gallatin, Bozeman
Broadwater, Townsend	Granite, Phillipsburg
Carbon, Red Lodge	Jefferson, Boulder
Custer, Miles City	Missoula, Missoula
Dawson, Glendive	Park, Livingston
Fergus, Lewistown	Powell, Deer Lodge
Flathead, Kalispell	Sweet Grass, Big Timber
	Teton, Chouteau

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon all students who have fulfilled the entrance requirements and who have satisfactorily completed the course as outlined in the following pages. The course for the first three years is required of all students. In the fourth year the work is in part required while some of the work is left to the choice of the student; each student is required to elect three afternoons of work from courses offered, this work to lead to a thesis either in Geology, Mining, or Metallurgy.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

COURSE OF STUDY

FRESHMAN YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term Hours per week.
Higher Algebra.....	3.....	3
Trigonometry	5.....	5
Chemistry, Lectures.....	3.....	3
Chemistry, Laboratory.....	6.....	6
English	2.....	2
Mechanical Drawing.....	9.....	9
Descriptive Geometry.....	2.....	2

SECOND SEMESTER.

	First term Hours per week.	Second term Hours per week.
Analytical Geometry.....	3.....	3
Descriptive Geometry.....	2.....	2
Chemistry, Lectures.....	3.....	3
Chemistry, Laboratory.....	9.....	9
English	2.....	2
Surveying	4.....	4
Mechanical Drawing.....	6.....	6

Surveying, summer course of six weeks.

SOPHOMORE YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term Hours per week.
Calculus	5.....	5
Physics	5.....	5
Chemistry, Lectures.....	1.....	1
Chemistry, Laboratory.....	11.....	11
Crystallography	8.....	0
Blowpipe Analysis.....	0.....	8

SECOND SEMESTER.

	First term Hours per week.	Second term Hours per week.
Calculus	4.....	3
Physics	3.....	4
Chemistry, Laboratory.....	9.....	9
Chemistry, Lectures.....	1.....	1
Descriptive Mineralogy.....	2.....	2
Determinative Mineralogy.....	5.....	5
Mine Surveying.....	3.....	3
Topographical Drawing.....	3.....	3

Mine Surveying, summer course of six weeks.

JUNIOR YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term Hours per week.
Mechanics	5.....	5
Machine Design.....	2.....	2
Dynamical Geology.....	5.....	0
Structural and Physiographical Geology	0.....	8
Metallurgy, Assaying.....	12.....	0
Metallurgy, Introduction.....	3.....	3
Gas Analysis.....	0.....	3
Testing Laboratory.....	3.....	0
Drawing, Designing.....	0.....	6
Metallurgical excursion to copper smelter, one week.		

SECOND SEMESTER.

	First term Hours per week.	Second term Hours per week.
Petrography	8.....	8
Historical Geology.....	3.....	3
Mechanics of Materials.....	3.....	3
Hydraulics	2.....	2
Mining	2.....	2
Metallurgy, Copper.....	3.....	3
Metallurgy, Laboratory.....	3.....	3
Engineering Design.....	6.....	6
Mining and metallurgical excursion, 2 weeks.		
Field Geology, summer course of six weeks.		

SENIOR YEAR

FIRST SEMESTER.

(Required Work.)

	First term Hours per week.	Second term Hours per week.
Economic Geology.....	5.....	5
Ore Dressing.....	0.....	3
Metallurgy of Gold and Silver....	3.....	3
Mining	2.....	2

(Optional.)

Mechanical Engineering of Power Plants.....	3.....	3
Graphic Statics.....	9.....	0
Engineering Design I.....	0.....	3
Engineering Design II.....	0.....	6
Engineering Design III.....	0.....	9
Metallurgical Laboratory I.....	3.....	3
Metallurgical Laboratory II.....	6.....	6
Applied Geology I.....	3.....	3
Applied Geology II.....	6.....	6
Journal Club.....	3.....	3

SECOND SEMESTER.

(Required Work.)

	First term Hours per week.	Second term Hours per week.
Mining	3.....	3
Metallurgy of Lead and Zinc.....	3.....	3
Engineering Construction.....	2.....	2

(Optional.)

Ore Dressing	2.....	2
Metallurgy Laboratory.....	3.....	3
Ore Dressing Laboratory.....	3.....	3
Mechanical Engineering of Power Plants	3.....	3
Engineering Design I.....	3.....	3
Engineering Design II.....	6.....	6
Engineering Design III.....	9.....	9
Applied Geology II.....	6.....	6
Journal Club.....	3.....	3

ENGLISH

MR. KNEISLY.

English Composition.—This is a course in the principles and practice of English composition. Lectures are given on the whole composition, paragraph and sentence; weekly themes and daily paragraphs are required; notes are taken on assigned readings. The work is intended to supplement the usual high school courses in composition. Instead of dealing with figures of speech and other rhetorical devices, however, it has to do more with the outline, unity, coherence, and emphasis, as applied to exposition and argumentation.

Freshman, first semester, two hours per week.

English—Technical Prose.—This is a continuation of the first course. Studies are made in the structure of modern prose; critiques and model paragraphs are written; lectures are given on words. Training in business correspondence is also given, and special studies made in technical vocabulary.

Freshman, second semester, two hours per week.

MATHEMATICS

PROFESSOR CRAVEN, PROFESSOR BOWMAN.

Algebra.—A short preliminary course is first given, designed to drill the student in the fundamental operations and in the statement and solution of problems. The following topics constitute the chief items for the term's work: Indeterminate coefficients; theory and use of logarithms; limits; introduction to derivatives; binomial and logarithmic series; tests of convergency of series; general theory of equations; solution of numerical equations.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and oblique triangles; practical problems. The solution of the right and oblique angled spherical triangles is developed and practical application is made to surveying and mensuration. The text book used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—In this course a systematic study is made of the following: The point and straight line in a plane; different systems of coordinates; conic sections; discussion of the general equation of the second degree with two variables; higher plane curves; the point and straight line in space; curved surfaces and surfaces of revolution. The text used is Wentworth's Analytic Geometry.

Freshman, second semester, three hours per week.

Calculus.—Among the topics studied in this course may be mentioned: Differentiations, Taylor's theorem; indeter-

minate forms; maximum and minimum; tangents, normals, and asymptotes; curvature and radius of curvature; integration; rectification of curves; areas; volumes; center of mass; moment of inertia. Application is made to numerous problems in mechanics during the latter part of the lectures. The text being presented in the form of lectures. The text book used is Differential and Integral Calculus, by Taylor.

Sophomore, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR LINCOLN AND MR. KNEISLY.

Crystallography.—The course in Crystallography consists of a short series of lectures supplemented by laboratory and drafting practice. One afternoon each week is devoted to crystal drawing and another to the examination of natural crystals and models. The aim is to familiarize the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. Moses and Parsons' "Elements of Mineralogy, Crystallography and Blowpipe Analysis" is used as a text-book both in this and in the succeeding courses in mineralogy.

Sophomore, first semester, first term, eight hours per week.

Blowpipe Analysis.—The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the course is to teach the student to use the blowpipe and to make other chemical tests of importance in mineralogy. This course is introductory to that in determinative mineralogy.

Sophomore, first semester, second term, eight hours per week.

Descriptive Mineralogy.—The course consists almost entirely of lectures and is a companion course to that in Determinative Mineralogy. Crystallography is a prerequisite. The introductory lectures take up the characters of minerals and the occurrence and origin of minerals, then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by assigning one hour each week during the latter part of the course to the examination of the exhibition specimens in the mineralogical museum. By this means the student learns to identify typical specimens by their external appearance alone. The object of the course as a whole is to make the student thoroughly familiar with the appearances, properties, associations, and uses of the economically important minerals and to give him some insight into the practical and scientific problems connected with mineralogy.

Sophomore, second semester, two hours per week.

Determinative Mineralogy.—This course consists entirely of laboratory work and thus supplements the contemporary

course in Descriptive Mineralogy. Blowpipe Analysis is a prerequisite. The operations and principles learned in the earlier course are in this course practically applied to the determination of mineral species. The aim of the exercises is to train the student to determine minerals with accuracy and rapidity by means of physical and chemical tests.

Sophomore, second semester, four hours per week.

Dynamical Geology.—Dynamical Geology is presented in a series of lectures which discuss the greater geologic processes:—eruption, deformation, erosion and sedimentation. Scott's "An Introduction to Geology" is used as a text-book.

Junior, first semester, first term, five hours per week.

Structural Geology.—This course occupies the first half of the second term in the Junior year. Descriptive Mineralogy is a prerequisite. The course consists of both lectures and laboratory exercises. Scott is used as a text, supplemented by Kemp's "Handbook of Rocks." There are sixteen lectures on the principles of structural geology and sixteen laboratory periods given over to the study of the more common types of igneous, sedimentary and metamorphic rocks. Through this laboratory work, the student becomes familiar with the common rocks and learns to identify them in so far as this can be done without the aid of the petrographical microscope.

Junior, first semester, first half of second term, eight hours per week.

Physiographical Geology.—The second half of the second term in the Junior year is taken up with physiographical geology. Both Dynamical Geology and Structural Geology are prerequisites. There are sixteen lectures on the relation of geologic processes to topography, and sixteen laboratory exercises in interpreting topographic maps and in drawing assigned topographic forms. Scott is supplemented by topographic and geologic maps published by the United States Geological Survey. The course is designed to render the student familiar with the topographical features of the earth and the modes in which they were produced.

Junior, first semester, second half of second term, eight hours per week.

Historical Geology.—This course consists of one lecture and two laboratory hours weekly. The course in Physiographical Geology is a prerequisite. The lectures take up the history of the earth, discussing changes of level between land and sea, of topography, of climate, and of the successive groups of animals and plants which have lived upon the globe. Special attention is paid to the geological history of Montana. The laboratory work includes a study of those fossils which are the most abundant and the most characteristic indices of the ages of different strata, the identification of unknown material and the working out of practical problems through the aid of fossils.

Junior, second semester, three hours per week.

Petrography.—This course consists of two lectures and two afternoons in the laboratory weekly for one semester. Struc-

tural Geology is a prerequisite. The course is introduced by a review of the principles of optics, after which optical mineralogy is studied for the remainder of the term. Johannsen's "Key to the Determination of Rock-Forming Minerals" is used as a text. The student becomes familiar with the use of the petrographical microscope and is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. The second term is devoted to the study of rocks and ore-bearing formations. Harter's "Petrology for Students" is used as a text-book. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers, and the student is taught to examine these hand specimens at the same time with the slides. This course affords the student an opportunity to become thoroughly familiar with the macroscopic and microscopic characters of the principal rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in Applied Geology.

Junior, second semester, eight hours per week.

Field Geology.—The course in Field Geology consists in the detailed study of the geology of a selected area. Historical Geology is a prerequisite. Instruction is given in observing, recording and interpreting geological phenomena, and in the preparation of geologic maps and sections. Upon completion of the field work, each student is required to submit promptly an accurate and detailed geological report on the area investigated.

Junior, summer course of six weeks.

Economic Geology.—The course in Economic Geology consists of lectures and drafting exercises. Structural Geology is a prerequisite. The lectures treat of the methods of occurrence, geological relations, origin and commercial value of the more important economic deposits of the world. Five lectures weekly for one semester are devoted to the subject. Stress is laid upon the ore deposits of the United States and specially upon those of Montana. Ries' "Economic Geology of the United States" is used as a text-book, strongly supplemented by lecture notes.

Senior, first semester, five hours per week.

Applied Geology I.—Mines and other points of geological interest in the neighborhood of Butte are visited and the facts observed set down in a note book. The data thus obtained are used in working out practical problems of a geological nature.

Optional. Senior, first semester, three hours per week.

Applied Geology II.—A problem in which geology plays an important part is worked out in detail and a thesis written upon it. As an example of the character of work required

by this course may be cited the geological and economic examination of a mine or mining district. When a problem of this nature is undertaken, it will usually be found distinctly advantageous to reserve one afternoon a week in addition to the time required for the course proper, this extra afternoon to be devoted to the solution of some problem in designing or metallurgy connected with the mine or district examined.

Optional. Senior, first and second semesters, six hours per week.

Journal Club.—One afternoon each week is devoted to the discussion of articles of special interest occurring in the current geological, mining and metallurgical journals.

Optional. Senior, three hours per week.

CHEMISTRY

PROFESSOR GILFILLAN, ASSISTANT PROFESSOR HARTZELL.

General Chemistry.—The subject of general chemistry is presented through lectures and text books. The object of the course is to develop the underlying principles of chemistry as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements, the work is also copiously illustrated with experiments conducted by the instructor. It is necessary that the student should take full notes on the lectures, which are designed to aid and direct the laboratory work of the same semester. Text book Remsen's College Chemistry.

Freshman, first semester, three hours per week.

General Chemistry, Laboratory.—The laboratory course in general chemistry consists in performing a large number of experiments by the students at individual desks. Aside from becoming proficient in the use of apparatus, the student becomes familiar with the different acids, bases and salts, their reactions and relations with each other. It is a part of the work to keep a neat notebook in which are recorded the reactions and statements of the principles involved in each experiment.

Freshman, first semester, six hours per week.

Qualitative Analysis.—The course in qualitative analysis is designed to instruct the students in the general schemes of analysis by which the different metals are detected and separated from each other. The problem of isolating and identifying the acid radicals is also a part of the course. The accompanying lectures give a general outline of the schemes of separation and deal with the merits and difficulties of each, finally pointing out the best method to be used by the mining engineer. The essential element of writing and balancing chemical equations is made a part of the drill work of the class. During the last part of the course the class is intro-

duced to the subject of stoichiometry. The text book used is Prescott and Johnston's "Qualitative Analysis."

Freshman, second semester, three classroom hours and nine laboratory hours per week.

Quantitative Analysis.—The course in quantitative analysis embraces a study of such analyses as the mining engineer meets in practicing his profession in the laboratories of smelters and mine plants. The main object in view is to develop the ability of the student to do this work with the accuracy and the rapidity required in practice, so that the student who completes the course need have no hesitancy to accept a position of this character.

Among the analyses performed may be mentioned the analysis of limestone, dolomites, feldspars, ores of iron, manganese, lead, zinc, arsenic, copper, etc. Analyses are made of mattes, flue dust, concentrates, calcines, and pig-iron. During the course some time is spent on acidimetry and alkalimetry. The laboratory work is performed by the students at individual desks where the best appliances and modern conveniences are at hand. The classroom work consists of discussions and quizzes on the theory of the laboratory work.

Sophomore, first semester, two hours classroom and nine hours laboratory work per week; second semester, ten hours per week.

METALLURGY.

PROFESSOR GILFILLAN, ASSISTANT PROFESSOR HARTZELL,
MR. ADAMI.

Introduction to Metallurgy.—The study of metallurgy begins with lectures and recitations on the fundamental principles of the art. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, product of combustion, etc., are studied. The various fuel, solid, liquid, and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast, reverberatory, muffle, and electric, used in metallurgical operations are studied. In connection with this the methods for utilizing waste heat are discussed. The efficiency of the various types of furnaces are calculated. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated. A few weeks are devoted at the end of the semester to the metallurgy of iron, text book, Robert-Austin "Introduction of Metallurgy;" L. S. Austin's "Metallurgy of the Common Methods."

Junior, first semester, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of the smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining matte in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations studied is required of each student.

Junior, second semester, three hours per week.

Metallurgy of Gold and Silver.—The first semester of the senior year is devoted to the metallurgy of gold and silver from lectures and text books. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The older metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiviation process are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student of the plant visited.

Senior, first semester, three hours per week.

Metallurgy of Lead and Zinc.—The subject of the metallurgy of lead is taken up the second semester of the senior year. The subject is presented in the form of lecture and text book work. The processes of roasting, pot-roasting and smelting of lead ores are discussed, as well as the refining of lead bullion by the Parkes and Pattison processes and by the Betts electrolytic process.

The metallurgy of zinc is treated more briefly and is followed by a short discussion of the methods of reducing aluminum, nickel, etc.

The lecture room work on lead and zinc is followed by metallurgical excursions to the lead smelter at Helena or the lead smelters at Salt Lake City and notes and reports required of the students covering the examinations made at these works.

Senior, second semester, three hours per week.

Assaying.—The subject is presented in the form of lectures with reference to text books. The practical work consists of the fire assaying of gold, silver and lead in all varieties of crude ores and smelter products, such as copper and lead slags, copper and lead matte, copper and lead bullion, lead dross and speiss, calcines, flue dust, tailings, etc.

The laboratory is fitted with the most modern appliances and it is a part of the aim of the course to give the student a thorough drill in accuracy and rapidity.

Junior, first semester, first term, twelve hours per week.

Gas and Fuel Analysis.—The student is taught to use the standard types of gas analysis apparatus and determine the commoner and more important constituents of furnace and smelter flue gases. The latter part of the course is taken up with the proximate analysis of coals and cokes and the determination of their heating power by means of the calorimeter.

Junior, first semester, second term, three hours per week.

Metallurgical Laboratory.—The work consists of a series of experiments illustrating various metallurgical processes. The changes which an ore undergoes when subjected to oxidizing or chloridizing roasting are investigated, as well as sulphatizing reactions. Some time is devoted to the measurement of high temperatures and a study of the melting points of silicates and slags. The electrolytic refining of copper is studied.

Junior, second semester, three hours per week.

Metallurgical Laboratory.—The laboratory work of the junior year is continued with practice in the methods of ore testing in the laboratory. Concentration, cyanide and chlorination tests are made with small quantities of ores, the tests being so made that reliable conclusions can be drawn as to what will take place on a large scale. Determinations are made on the proportions of sand and slime produced in crushing ores, the most economical size to crush to, most economical strength of solution to use, cyanide consumption, etc.

Senior, first semester, three or six hours per week.

Ore Testing Laboratory.—The laboratory work of the senior year consists of tests on bulk parcels of ore in order to determine the most suitable methods of treatment. Experiments are also made with a view of testing improved or new processes of extracting metals from their ores. The ore testing building is equipped with crushing and concentrating plant, cyanide and chlorination plant, in which lots of several tons of ore at a time can be treated. There is also a wedge roasting furnace, a Bruckner calciner and a reverberatory furnace. The work at the metallurgical plant is checked by sampling and assaying.

Senior, second semester, three or six hours per week.

MECHANICS.

PROFESSOR BOWMAN, PROFESSOR CRAVEN.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion, inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text books used are: Elements of Mechanics, by Merriman; Elementary Lessons in Heat, by Tillman.

Sophomore, first semester, five hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met with in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Electrical Catechism, by Shepardson, is used as a text book.

Sophomore, second semester, six hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; canti-

lever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc. Merriman's *Mechanics of Materials* is used as a text book.

Junior, first semester, three hours per week; second semester, two hours per week.

Applied Mechanics.—It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, supports for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application to mining machinery is found in the catalogues furnished us by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte.

Junior, first semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the west. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's *Treatise on Hydraulics* is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course a systematic study is made of the mechanism of engines, non-condensing, condensing, simple, and continuous expansion engines, valves, and valve gearing with

their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power houses are also made a part of this course.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr. The text book used is Steam Engines and Boilers, by Kenneally.

Senior, first semester, three hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the Sophomore year. In the Senior year the student's attention is directed to the general conditions of power transmission, power transmission by continuous current, some properties of alternating circuits, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is Power Transmission, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the Junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening,—a roof, bridge, or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due to a locomotive, also stresses due to wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. Steel Mill Buildings, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Senior, first semester, first term, nine hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: details of mill building, both frame and steel; constructions

of retaining walls, foundations, dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum's Steel Mill Buildings.

Senior, second semester, two hours per week.

MINING AND ORE DRESSING.

PROFESSOR SIMONS, MR. ADAMI.

Instruction in the various branches under this department is given by lectures and recitations, by excursions to mines, mills, and smelters within easy reach of the students, by field work in surface and underground surveying, and by practical work in and about mines during the summer vacation.

Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requiring a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, four hours per week.

Surveying.—A course of lectures and recitations on underground surveying and on surface surveys; including location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating quantities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, three hours per week.

Surveying.—A six weeks' trip in the field by the Freshmen, at the end of the second Freshman semester. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Exercises in pacing, ranging and chaining and solution of geometrical problems with the chain. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth, and deflection. Problems in public land surveying in accordance with Manual of Instruction to U. S. Deputy Surveyors. Official survey of mining claims in applica-

tion for U. S. patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to U. S. Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Determination of elevations by aneroid barometer. Staking out buildings and excavations for foundation and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Freshman, summer course of six weeks.

Surveying.—A six weeks' trip in the field by the Sophomores at the end of the second Sophomore semester. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and Polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shaft by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the coordinates for each station N., S., E. and W. of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods. Four weeks are spent exclusively in surveying and mapping; the remaining two weeks are devoted to the study of mining operations at the mine.

Sophomore, summer course of six weeks.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines, where mining operations are observed.

Junior, second semester, two hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, first semester, second term, two hours per week.

Mining.—First part: Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Ventilation, natural and artificial. Lighting and sanitary arrangements.

Second part: The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, three hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Description of the construction and operation of typical crushing machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

Seniors, second semester, two hours per week.

DRAWING AND DESIGNING.

PROFESSOR SIMONS, PROFESSOR BOWMAN, MR. ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The following list is recommended; other minor necessities may be supplied as suggested later by the instructor: One $5\frac{1}{2}$ inch compass, one $3\frac{1}{4}$ inch bow divider, one $3\frac{1}{4}$ inch bow pencil, one $3\frac{1}{4}$ inch bow pen, one 5-inch ruling pen, one 8-inch $30^{\circ}\times 60^{\circ}$ amber triangle, one 8-

inch 45°x45° amber triangle, one 12-inch architect's triangular scale, one T-square—36-inch blade, one drawing board 24x32 inches.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshman, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subjects laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, with the conventions used in mine and geological maps, and many other useful items used in mining. The text books are the same as used in the first course.

Freshman, second semester, six hours per week.

Topographical Drawing.—This subject follows the practical field surveying of the Freshman class. The work consists in platting on a convenient scale the surveys executed in the field. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders, and north points, and general neatness in execution.

Sophomore, second semester, six hours per week.

Machine Design.—This course is an application of the material presented in the second course in applied mechanics. The object is to give instruction in machine drawing so that repair parts for hoists, crushers, rolls, stamps, etc., may be correctly designed and represented. Attention is given to conventions, sections, correct lettering, and dimensioning. The problems are given entirely by dictation. Machine Design, by Low and Bevis, and Kent's Mechanical Engineer's Hand Book are used as reference books. Several copies of these volumes are to be found on the tables of the drawing room.

Junior, first semester, second term, two hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, second semester, six hours per week.

Mining Engineering Design.—I. Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogues and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, three hours per week.

Mining Engineering Design.—II. and III. are along the same lines as course I., the work in the higher courses being more extensive and requiring six and nine hours of work per week respectively, for the second term of the first semester and for both terms of the second semester.

Senior, all year, six or nine hours per week.

Sketch Club.—The name of "Sketch Club" has been applied to the classes which go on trips during the second semester to visit the mines and smelters of the city. The students are accompanied by at least two professors, who

point out items of interest and assist the students in sketching standard engineering devices which may be of use in after practice. The students are taught to observe operations with an engineering interest, which is a most beneficial habit to acquire.

Senior, second semester, three hours per week.

MINING LAW.

LECTURER, JOHN B. CLAYBERG.

A short course of lectures on mining law, particularly in regard to the rights of prospectors, the apex rights, water rights, the location of placer and lode claims, and the lateral rights of the locator as determined under the laws of the United States and the State of Montana. The course consists of fifteen lectures and is required of juniors and seniors. The course is given every other year. Was given in 1908-1909.

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the legislature of the state. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the school. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. Fortunately it does not demand an extensive equipment. At the School of Mines it is furnished merely with a large recitation and lecture room on the second floor, abundantly supplied with blackboard space, and with slate, terrestrial and celestial globes, some simple models and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY AND METALLURGY

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been

devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qualitative and quantitative analysis, one for metallurgy, and two professors' laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of students in the laboratories. These balances are placed on stands which rest on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The professors' laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the students in the laboratories and all check analysis on the students' work are made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast and a direct and alternating current of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The ore dressing room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a buckboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold, and silver ores, together with mattes, both copper and lead, slag, flue-dusts, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state. Each student is required to collect, crush, grind and buck five twenty-five pound samples in the assay course, and to cut down and assay these samples.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverbaratory or muffle roasting furnace, where large lots can be simply calcined, or a chlorination roast can be made by the hyposulphite treatment. There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

A very complete set of the products of the metallurgical processes in use at the Boston & Montana smelter at Great Falls is installed in one of the Mineralogical Museum cases; this includes an exhibit of electrolytic slime together with ingots showing the exact amount of copper, silver and gold recovered from a definite amount of this slime. There are also several views of the interior of the smelter and adjoining properties, as well as a flow sheet of the concentrator connected with the plant.

The Butte Reduction Works is represented by a large number of its metallurgical products, including concentrates, tailings, mattes, sulphur-coated ore, etc. The products of the Washoe smelter are also present, including samples of the copper cakes and anodes produced at Anaconda.

In addition to the mine models there are two metallurgical models in the Mineralogical Museum; one is a model of the Holthoff-Wethey calcining furnace, as in use at the Butte Reduction Works, showing the device by means of which the rails and wheels supporting the harrows are kept outside of the furnace proper; the other is a model of the Pratt centrifugal ore sizer for sizing ore before it is run over Wilfley tables.

Several appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, of the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls, and of various mines and mills about the State. In addition, there is a large drawing to illustrate the method of sampling in use at the Washoe Sampling Works, and several drawings of the coal washery of the Cottonwood Coal Company.

The new ore testing and metallurgical laboratory occupies a separate building, 77 by 70 feet, half of which is devoted to metallurgical work. This contains complete cyanide and chlorination plants, a wedge roasting furnace, a Bruckner calciner, a reverberatory furnace and other accessory appliances for metallurgical investigations capable of dealing with several tons of ore at a time.

Storage bins for ores, slags, etc., are provided and an adjoining room is being fitted up for electro metallurgical work, pyrometry, etc.

DEPARTMENT OF MINING AND ORE DRESSING.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy four large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following have been provided: Six engineering transits; one from Buff and Buff, one from C. L. Berger & Sons, three from Gurley, and one from Keuffel and Esser. Four levels—one from Buff, one from Gurley, one from Keuffel and Esser and one from Berger. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plummets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight inch by twelve inch Dodge crusher, two sets of twelve and one-half inch by twelve inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs, Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four hundred pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures

on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the school library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very instructive section through part of the Great Falls concentrator, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

General.—The Department of Geology and Mineralogy occupies eight rooms and part of three others. On the first floor is the Geological Museum with its overflow accomodated in a neighboring lecture room; on the second floor are the Office, the Lecture Room and the Mineralogical Laboratory, while certain maps are provided for in the library; and on the third floor are the Mineralogical Museum, the Thin-Section Lathe Room, the Dark Room and the Storage Room; while a collection of geological mine models occupies part of a drafting room.

The collections of minerals, of rocks, of fossils, of ore, and country-rocks, belonging to the department have each been subjected to a threefold division into museum specimens, lecture specimens and student specimens. The student collections are placed in drawers where they are accessible to the students at all times; the lecture specimens are kept in the office, where they may only be examined in the presence of an instructor; and the museum collections, which consist of the rarer, the larger and more delicate specimens, are kept under the glass where they may be seen but not handled.

Of general usefulness in all courses of the Department of Geology and Mineralogy are the Storage Room, the Dark Room, the Lecture Room and the

Office. These rooms and their contents will now be described, with the omission of certain special apparatus and collections which are more consistently described later. The Office is twenty-two feet long by twenty feet wide. It is fitted with desks and tables for the convenience of officers of the department, with cabinets for the various lecture collections and with book-cases for the departmental library. The Lecture Room is provided with large blackboards and furnished with a suitable desk and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. The Dark Room on the third floor contains apparatus and chemicals for photographic work. The Storage Room on the same floor contains materials for the museums or class-rooms which has not yet been prepared for study or exhibition.

Mineralogy.—The large set of crystals included in the lecture collection of minerals is used not only to illustrate the lecture in Crystallography but also as material for laboratory exercises. In addition to these real crystals, three series of crystal models are available, two of wood and one of celluloid. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the Mineralogical Laboratory. The stereographic projection of models and crystals is performed in the Mineralogical Museum.

The Mineralogical Museum contains the museum collection of minerals. This has been separated into two parts; a systematic collection arranged according

to Dana and an economic collection arranged according to Moses and Parsons. A collection of gold crystals belonging to the museum is ordinarily kept in a vault. It consists of about one hundred and fifty specimens collected from about twenty million dollars' worth of placer gold which passed through the Helena assay office in former years. The museum is thirty-one-foot square and only a third of the floor space is occupied by the six cases of minerals. The remainder of the room is at present used as a drafting room.

The Mineralogical Laboratory is thirty-one feet square and contains six laboratory tables capable of accomodating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains a set of one hundred and seventy-seven specimens illustrating the physical characters of minerals. In another corner stands a cabinet containing two hundred and eighty-eight mineral species and varieties arranged according to Moses and Parsons. Pycnometers, Westphal balance, Plattner scales, burettes, agate mortars, and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here will also be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks.

Geology.—The Geological Museum occupies a room thirty-one feet square and four plate glass cases belonging to the museum have been placed in an adjoining lecture room. The museum has tables arranged next the windows on three sides and the remainder of the room is occupied by cases and cabinets.

For laboratory work in Structural Geology, there are two large cabinets, each containing thirty drawers, in which is kept the student-rock collection arranged according to Kemp. Immediately above these drawers, arranged beneath glass, are series of rocks illustrating the more important structures and types. The lecture demonstration of different types of faulting is effected by the aid of a series of wooden models kept in the Office.

The laboratory exercises in Physiographical Geology are conducted on the tables in the museum. Two large cabinets, containing geologic and topographic maps respectively, furnish the material for this work. These cabinets are kept in the School Library.

Historical Geology laboratory exercises are also carried on the museum. One case is filled with the larger and more perfect fossils.

Although laboratory work in economic geology is not required in the course at the School, nevertheless a student collection of specimens of economic interest has been placed in the Geological Museum and is utilized in connection with the course in Economic Geology. Like the student rock collection, it occupies sixty drawers, and above it in glass cases have been placed some of the more interesting economic specimens. There are ten other show cases containing specimens belonging to the museum economic collection. The collection embraces specimens of copper ores from all the large mines of Butte, comprising average and picked samples, samples which are mixtures of several ore-minerals and those showing massive or crystalline varieties of a single mineral, specimens of the country rocks, mineral veins and slickensided samples of ore. In addi-

tion to the collection of Butte ores, there is a large collection of specimens of coal and of gold, silver, copper and lead ores from the various mining districts of Montana. Besides this, there are samples of graphite, coke, molybdenite, scheelite, corundum, limonite, onyx, clay, gypsum, mineral paint, and oil from various parts of the state. Whenever possible these specimens were placed beside samples from other states for purposes of comparison. A fine set of ores, minerals and country rocks from the Lake Superior iron ranges has recently been donated by Mr. F. A. Glass, a former student.

Upon the wall of the Geological Museum hangs a colored diagram representing an "Ideal Section of a Butte Copper Vein." This was constructed by the Geological Department of the Anaconda Copper Mining Company and has been reproduced in print several times. The Lecture Room walls are hung with diagrams showing the relative production of various metals in Montana and other states, and a map made at the School showing all the important mineral districts of Montana. In one of the drafting rooms there is a fine set of geological mine models.

For the summer work in Field Geology, the department is equipped with a transit, a level, seven Brunton compasses, three aneroid barometers, geological hammers, tapes, a camera, Attwood clinometer, Abney mine level and a Keuffel and Esser compass and clinometer. A complete camp outfit is owned jointly with the Department of Mining Engineering.

Petrography.—In the Geological Museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type made by Leitz in Wetzlar. These microscopes are all pro-

vided with the necessary attachments for ordinary petrographic work, and two of them, one Leitz and one Nachet, are of larger size than the others and are equipped with accessories for research work. The School has just purchased from Fuess a very fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the museum contains two hundred and fifty-eight oriented slides of minerals, six hundred and thirty-nine thin sections of rocks, and seventy-four slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of the fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are almost all represented by hand specimens in the student collection of rocks (which is kept in this museum and has already been described), so that the student may observe the macroscopic character of the same rocks whose microscopic characters he is studying. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall-case.

The Thin-Section Lathe Room contains complete equipment for making thin sections of rocks and minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a wire and also with a wheel, both for cutting slices.

Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the Dark Room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes. Wheatstone bridges, galvanometers, batteries, keys, etc.

The engine and dynamo room is located in the basement of the building; there is installed here a gas engine of fifteen horsepower, from which is belted a line shaft driving direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any

number of them may be connected to any of the circuits for lecture or experimental purposes. The requisite voltmeters and ammeters for both alternating and direct current, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

In connection with this laboratory there is a small shop equipped with the following metal working machines; one thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression and shearing tests. The accessories consist of the following: One Olson compression micrometer especially designed for measuring the compression of stone cubes and other building material; one Olson improved deflection instrument for measuring the deflection of beams subjected to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

The number of publications in the library, departmental and others, is nearly 4,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; and Engineering Corps. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, and geological magazines, are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers.

A valuable collection of the standard works and treatises on the various branches of science taught in technical schools has been secured by donation.

MAGAZINES.

The following technical and general magazines and periodicals will be found in the library and in the rooms of the members of the faculty, where they may be freely consulted by the students:

American Journal of Science.
 Bulletin of the Geological Society of America.
 Cassier's Magazine. Collier's Weekly.
 Century. Economic Geology.
 Chemical Abstracts. Electrical World.
 Chemical News. Electrical Age.
 Electrochemical and Metallurgical Industry.
 Engineering.
 Engineering and Mining Journal.
 Engineering News.
 Harper's Weekly.
 Harper's Magazine.
 Iron Age.
 Iron and Steel Magazine.
 Iron Trade Review.
 Journal of the American Chemical Society.
 Journal of the Association of Engineering Societies.
 Journal of the Chemical Society of London.
 Journal of Geography.
 Journal of Geology.
 Journal of the Geological Society of Tokio.
 Machinery (Engineering Edition).
 Mineral Industry.
 Mineralogical Magazine.
 Mines and Minerals.
 Mining and Scientific Press.
 Mining Reporter.
 Mining World.
 National Geographical Magazine.
 Nature.
 Neues Jahrbuch fur Geologie, Mineralogie, etc.
 Outlook.
 Popular Science Monthly.
 Quarterly Journal of the Geological Society of London.
 Salt Lake Mining Review.
 Scribner's.
 School of Mines Quarterly.
 Transactions of the American Institute of Mining Engineers.
 Tschermak's Mineralogische und Petrographische Mittheilungen.

The following newspapers are kindly furnished by their publishers free of charge:

The Ravalli Democrat (weekly), Hamilton.
 Great Falls Leader (daily), Great Falls.
 The Missoulian (daily), Missoula.
 The Tribune-Review (weekly), Butte.
 The Basin Progress (weekly), Basin.

GENERAL INFORMATION.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given to this locality such publicity that no one now needs to be told of its leading position in the mining world.

Following a long period in which its mineral product, though larger than that of any other field, was kept far below its capacity by reason of conflict of title to mining ground, a settlement has been effected which will permanently remove all such restriction in its output. New life has been infused, new mines located, and such aggregations of capital have been enlisted as promise a vast increase in its production for a generation to come. With this increase in production, there has come a largely increased demand for copper, and a consequent advance in prices, that must for some years to come make the mining of the red metal in Butte one of the most profitable industries of the world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city must be enlarged to treat the enlarged product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and

all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with all the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the very extensive mining and metallurgical plants in the vicinity of the school.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter; the opportunity is here presented for daily observation of works, the development and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the school under the guidance of their instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given

to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the freshmen spend six weeks of their summer vacation time in camp, where they are given fifty hours per week in learning the use of instruments, and in such exercises as are detailed on page 30. The sophomores, in like manner, spend six weeks of their summer vacation in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior class spends six weeks making geological surveys in some one of the interesting geological fields of this and adjoining states.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

EXPENSES

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deductions will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the student, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order. The balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR

General Chemistry and Qualitative Analysis.....	\$15.00
Surveying	10.00

SOPHOMORE YEAR

Quantitative Analysis.....	\$15.00
Mineralogy	10.00

JUNIOR YEAR

Metallurgy and Assaying.....	\$10.00
Mine Surveying.....	10.00
Petrography	\$10.00

SENIOR YEAR

Metallurgy	10.00
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When the breakage exceeds the deposit the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as are approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15 to \$25 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

LIST OF STUDENTS

Graduate Students

Archibald, George B.	Butte, Montana
Mackel, Louis	Butte, Montana

Senior Class

Brulo, William	Helena, Montana
Evans, James	Butte, Montana
Gilham, Ralph E.	Townsend, Montana
Haines, Peter	Westresand, Lofotén, Norway
Harlan, Clyde C.	Kansas City, Missouri
Johnstone, J. Clark	Butte, Montana
Kane, Edward P.	Butte, Montana
Kirby, Kenneth P.	Butte, Montana
Little, David	Portland, Oregon
Loughran, Michael	Butte, Montana
Malloy, Edward E.	Butte, Montana
Peters, Ira B.	Butte, Montana
Stockett, Norman A.	Hosmer, B. C., Canada
Weigenstein, Henry J.	Butte, Montana
Williams, Daniel J.	Seattle, Washington
Young, William A.	Giltedge, Montana

Junior Class

Condon, George	Anaconda, Montana
Dyer, Burt W.	Livingston, Montana
Grunert, August	Butte, Montana
Heimerdinger, Vern	Butte, Montana
Howell, Henry	Butte, Montana
Jensen, Walter H.	Great Falls, Montana
Ralston, Edward L.	Dewey, Montana
Sherman, H. C.	Helena, Montana
Stuewe, William	Helena, Montana
Sullivan, George	Butte, Montana

Sophomore Class

Clinch, Ralph S.	Butte, Montana
Dailey, LeRoy N. A.	Great Falls, Montana
Gottschalk, Charles	Helena, Montana
Hubert, Ernest E.	Missoula, Montana
Kyle, Walter A.	Butte, Montana
McElvenny, Linden	Butte, Montana
Murphy, James K.	Butte, Montana
Ragen, William G.	Townsend, Montana
Roach, James C.	Butte, Montana
Sultzner, H. D.	Butte, Montana
Tout, Charles	Butte, Montana
Zentner, Arthur	Butte, Montana

Freshman Class

Andrew, John T.....	Butte, Montana
Christian, O. B.....	Butte, Montana
Clinch, W. D.....	Butte, Montana
Cohen, Jesse.....	Anaconda, Montana
Craig, George L.....	Butte, Montana
Cosgrove, Mack.....	Butte, Montana
Cullity, Emmett.....	Indianapolis, Indiana
Fowler, George M.....	Lewistown, Montana
Gervais, Paul.....	Anaconda, Montana
Gidel, Murl.....	Butte, Montana
Giovanetti, Ettare.....	Butte, Montana
Grupe, Charles W.....	Vancouver, B. C.
Hansen, Clinton J.....	Kalispell, Montana
Kirk, Cassius L.....	Salesville, Montana
Levinski, Alex.....	Butte, Montana
McAuliffe, Walter.....	Butte, Montana
Newton, Lucian C.....	Butte, Montana
Pierse, Edwin A.....	Great Falls, Montana
Tilton, Howard.....	Butte, Montana
Voyer, Guy C.....	Anaconda, Montana
Williams, Paul.....	Butte, Montana
Wright, Fred Sylvester.....	Belt, Montana

Special Students

Corr, Frank R.....	Butte, Montana
Davis, J. F.....	Dawson, Alaska
Emily, Joel.....	Portland, Oregon
Farnham, LeRoy S.....	Butte, Montana
Fogarty, Edmond A.....	Sandcliffs, Montana
Haldorn, Stuart.....	Butte, Montana
Hartsuck, Benjamin J.....	Olympia, Washington
Johnson, Robert M.....	Butte, Montana
Peterson, Evert.....	Butte, Montana

REGISTER OF ALUMNI.

Class 1903

Bender, Louis V.....Anaconda, Montana
Head Chemist, Anaconda Copper Mining Co.

Class 1904

Balmforth, Alfred J.....Tombstone, Arizona
Mining Engineer, Old Glory Mining Co.

Duling, Fred J.....Skidoo, California
Engineer, Skidoo Mining Co.

Irelan, Arthur J.....Helena, Montana
Mining Engineer, County Surveyor.

Kuphal, Henry E.....Helena, Montana
Professor Helena High School.

MacRae, Lachlan D.....
Mining Engineer.

Stevenson, Isabel Little.....Sumpter, Oregon

McGee, John.....Rawhide, Nevada
Mining Engineer.

Pauly, P. L.....Basin, Wyoming
Mining Engineer.

Reese, Clara Clark.....Denver, Colorado

Tallant, H. S.....Deer Lodge, Montana
Mining Engineer.

Class 1905

Archibald, George.....Butte, Montana
Mining Engineer, Butte & Bacorn Mining Co.

Brinton, O. F.....Edgemont, Nevada
Mining Engineer, Montana Mining Co.

Corey, Clarence R.....Seattle, Washington
Assistant Professor of Metallurgy, University of Washington.

Duthie, John M.....Butte, Montana
Mining Engineer.

Elford, Basil.....Tonopah, Nevada
Mining Engineer and Assayer.

Mackel, Louis C.....Butte, Montana
Mining Engineer, Boston & Montana Mining Co.

Pratt, Paul D.....Libby, Montana
Mining Engineer.

Stevenson, Leon C.....Sumpter, Oregon
Manager, Orleans Gold Mining Co.

Van Gundy, Jay.....Wardner, Idaho
Mining Engineer, Federal Lead Co.

Class 1906

Dugan, John F.....Butte, Montana
Surveyor, Anaconda Copper Mining Co.

Feeney, Charles W.....Butte, Montana
Surveyor, Anaconda Copper Mining Co.

Geiser, Herbert S.....Butte, Montana
Butte Reduction Works.

Class 1906—(Continued)

Johns, John W.....	Butte, Montana
<i>Surveyor, Barker & Wilson.</i>	
Kane, Louis N.....	Butte, Montana
<i>Foreman, Berkeley Mine.</i>	
Warfield, Herschel J.....	Butte, Montana
<i>Draftsman, Boston & Montana Mining Co.</i>	
Wilson, Bert T.....	Wardner, Idaho
<i>Mining Engineer.</i>	
Young, Siegfried A.....	Hereford, Arizona
<i>Mining Engineer, Butte & Arizona Mining Co.</i>	
Young, Arthur B.....	Hereford, Arizona
<i>Mining Engineer, Butte & Arizona Mining Co.</i>	

Class 1907

Adami, Arthur E.....	Butte, Montana
<i>Instructor, Montana State School of Mines.</i>	
Bovett, Clifford A.....	Yerington, Nevada
<i>Mining Engineer.</i>	
McCracken, Ralston H.....	Butte, Montana
<i>Boston & Montana Mining Co.</i>	
Reardon, Daniel.....	Butte, Montana
<i>Mining Engineer.</i>	
Schafer, William A.....	Rawhide, Nevada
<i>Mining Engineer.</i>	

Class 1908

Bowden, Malcolm.....	Elkhorn, Montana
Ellis, Willis H.....	Great Falls, Montana
<i>Boston & Montana Mining Co.</i>	
Foote, Frank A.....	Butte, Montana
Ketcham, Samuel H.....	Komo, Montana
<i>General Engineering.</i>	
Lomas, Percy.....	Butte, Montana
Lowry, Thomas M.....	Butte, Montana
<i>Mining Engineer.</i>	
McLaughlin, William D.....	Butte, Montana
<i>Mining Engineer, Red Metal Mining Co.</i>	
Meikeljohn, Archie B.....	Butte, Montana
<i>Mining Engineer, Red Metal Mining Co.</i>	
O'Brien, Albert.....	Butte, Montana
<i>Surveyor, Harper & McDonald.</i>	
Patten, Earle.....	Butte, Montana
<i>Assayer, Boston & Montana Mining Co.</i>	
Proctor, Jr., Israel O.....	Placerville, Idaho
Proctor, Merton D.....	Elkhorn, Montana
Schiffner, Otto E.....	Ruby, Montana
Villars, Jesse R.....	Great Falls, Montana
<i>General Engineering.</i>	
Walton, Lee M.....	Butte, Montana
<i>Mining Engineer.</i>	
Wren, Andrew A.....	Denver, Colorado

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MONTANA STATE SCHOOL OF MINES

BUTTE, MONTANA

1910-1911

1909-10

UNIVERSITY OF ILLINOIS

PRESIDENT'S OFFICE

LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

AUG 12 1910

MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

UNIVERSITY OF ILLINOIS

PRESIDENT'S OFFICE

NINTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1909-1910

WITH ANNOUNCEMENTS FOR THE YEAR
1910-1911

CALENDAR FOR 1910-1911

1910.

May 31 to June 30, Mine Surveying, Sophomores.
July 18 to August 27, Field Work in Geology, Juniors.
July 1 to July 31, Field Work in Surveying, Freshmen.
August 29, First Semester begins.
October 28, Close of First Term.
October 31, Second Term, First Semester begins.
November 24-25, Thanksgiving Recess.
December 23, End of First Semester.

1911.

January 3, Second Semester begins.
February 22, Washington's Birthday.
March 17, End of First Term, Second Semester.
March 20, Second Term, Second Semester begins.
June 2, Commencement Day.
June 3 to July 3, Mine Surveying, Sophomores.
July 10 to August 19, Field Work in Geology.
July 5 to August 5, Field Work in Freshmen Surveying.
September 4, First Semester begins.

1910							1911							1912						
JULY							JANUARY							JULY						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
3	4	5	6	7	8	9	1	2	3	4	5	6	7	2	3	4	5	6	7	8
10	11	12	13	14	15	16	8	9	10	11	12	13	14	9	10	11	12	13	14	15
17	18	19	20	21	22	23	15	16	17	18	19	20	21	16	17	18	19	20	21	22
24	25	26	27	28	29	30	22	23	24	25	26	27	28	23	24	25	26	27	28	29
31							29	30	31					30	31					
AUGUST							FEBRUARY							AUGUST						
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28	29	30	31				26	27	28					27	28	29	30	31		
SEPTEMBER							MARCH							SEPTEMBER						
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18	19	20	21	22	23	24	19	20	21	22	23	24	25	17	18	19	20	21	22	23
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OCTOBER							APRIL							OCTOBER						
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16	17	18	19	20	21	22	16	17	18	19	20	21	22	15	16	17	18	19	20	21
23	24	25	26	27	28	29	23	24	25	26	27	28	29	22	23	24	25	26	27	28
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DECEMBER							JUNE							DECEMBER						
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25	26	27	28	29	30	31	25	26	27	28	29	30		24	25	26	27	28	29	30

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Secretary of the Board.

ALBERT J. GALEN, Attorney General.

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LESTER J. HARTZEL, E. M.,
Professor of Chemistry.

EDWARD B. HOWELL, A. M., LL. B.
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Instructor in Surveying and Drawing.

G. COOPER STALEY, A. B.,
Instructor in Mathematics and Mechanics.

CHARLOTTE RUSSELL,
Librarian and Registrar.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It was a significant date, and it marks the first national provision for education in the interest of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the best interests of the entire people.

The first Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight other members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The Legislative Assembly of the State of Montana passed an act early in the year 1895 providing for the establishment of a State School of Mines. This act provided for a Board of Trustees to be chosen by the State Board of Education. To the Board of Trustees is committed the immediate supervision of the School of Mines; the adoption of a course of study and the election of officers and members of the faculty; but all of the acts of this body are subject to the approval of the State Board of Education. The Trustees hold office for a term of four years. This act of the State Legislature also provided for the location of the School of Mines at Butte, the mining center of the State.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the campus overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the school. The building was erected during the years 1896 and 1897 through the use of funds advanced by the citizens of Butte, who were repaid in full when the bonds were finally issued in 1900. The bonds issued amount to \$120,000, bearing five per cent interest, and maturing in thirty years, but payable in fifteen years at the option of the State. These bonds are secured by the land endowment of the School.

The Legislative Assembly of 1907 appropriated \$59,000 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed during the summer of 1908.

The buildings of the State School of Mines are of red brick, with stone foundations and trimmings. The main building is three stories above the basement; it faces toward the east, overlooking the city. The length along the front is one hundred and eighteen feet and the depth ninety-four feet. The building contains 37,000 feet of available floor space and is almost entirely of fire proof construction.

The basement of the building is used by the Chemical and Metallurgical departments and the Mechanical testing laboratory. The first floor is given to the offices and to lecture rooms and the laboratory of the Department of Physics. On the second floor are the offices and lecture rooms of the departments of Mining and Geology, the Mineralogical laboratory, and the Library. The third floor is used for the freshman and sophomore drawing rooms and for the thin section room. Several store rooms

and a well-equipped dark room for photographic work are also on this floor.

The Metallurgical building is just west of the main building, the two being connected by a tunnel from the basement of the main building. The new building is one hundred and ten feet by seventy-two feet. A portion in which are the boilers and engine room is two stories high, while that portion containing the ore dressing and metallurgical laboratory is one room with available height of thirty-four feet. The laboratory is equipped with the apparatus to make tests on lots of ore in quantities ranging from one to ten tons.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1911, is \$33,000 per year.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The School is, therefore, wholly a technical one, not providing an education for the business man, the farmer, or the literary man but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind. Those who complete this course will receive the degree of Engineer of Mines.

REQUIREMENT FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed

by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which he comes.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

LIST OF ACCREDITED HIGH SCHOOLS IN THE STATE OF
MONTANA.

City High Schools.

Anaconda	Fort Benton
Billings	Great Falls
Butte	Helena
Chinook	Havre
Forsyth	Virginia City
Columbus	

County High Schools.

Beaverhead, Dillon	Granite, Phillipsburg
Broadwater, Townsend	Jefferson, Boulder
Carbon, Red Lodge	Missoula, Missoula
Custer, Miles City	Park, Livingston
Dawson, Glendive	Powell, Deer Lodge
Fergus, Lewistown	Sweet Grass, Big Timber
Flathead, Kalispell	Teton, Choteau
Gallatin, Bozeman	

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon all students who have fulfilled the entrance requirements and who have satisfactorily completed the course as outlined in the following pages. The course for the first three years is required of all students. In the fourth year

the work is in part required while some of the work is left to the choice of the student; each student is required to elect three afternoons of work from courses offered, this work to lead to a thesis either in Geology, Mining, or Metallurgy.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

COURSE OF STUDY.

FRESHMAN YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Higher Algebra.....	3	3
Trigonometry	5	5
Chemistry, Lectures.....	3	3
Chemistry, Laboratory.....	6	6
English	2	2
Mechanical Drawing.....	9	9
Descriptive Geometry.....	2	2

SECOND SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Analytical Geometry.....	3	3
Descriptive Geometry.....	2	2
Chemistry, Lectures.....	3	3
Chemistry, Laboratories.....	9	9
English	2	2
Surveying	4	4
Mechanical Drawing.....	6	6

Surveying, summer course of four weeks.

SOPHOMORE YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Calculus	5	5
Physics	5	5
Chemistry, Lectures.....	1	1
Chemistry, Laboratory.....	11	11
Crystallography	8	0
Blowpipe Analysis.....	0	8

SECOND SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Calculus	4	3
Physics	3	4
Chemistry, Laboratory.....	9	9
Chemistry, Lectures.....	1	1
Descriptive Mineralogy.....	2	2
Determinative Mineralogy.....	5	5
Mine Surveying.....	3	3
Topographical Drawing.....	3	3

Mine Surveying, summer course of four weeks.

JUNIOR YEAR

FIRST SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Mechanics	5	5
Machine Design.....	2	2
Dynamical Geology.....	5	0
Structural and Physiographical Geology	0	8
Metallurgy, Assaying.....	12	0
Metallurgy, Introduction.....	3	3
Gas Analysis.....	0	3
Testing Laboratory.....	3	0
Engineering, Design.....	0	6

Metallurgical excursion to copper smelter, one week.

SECOND SEMESTER.

	First term Hours per week.	Second term. Hours per week.
Petography	8	8
Historical Geology.....	3	3
Mechanics of Materials.....	3	3
Hydraulics	2	2
Mining	2	2
Metallurgy, Copper.....	3	3
Metallurgy, Laboratory.....	3	3
Engineering Design.....	6	6

Metallurgical excursion, two weeks.

Field Geology, summer course of six weeks.

SENIOR YEAR

FIRST SEMESTER.

(Required Work.)

	First term Hours per week.	Second term. Hours per week.
Economic Geology.....	5	5
Ore Dressing.....	0	3
Metallurgy of Gold and Silver....	3	3
Mining	2	2
Engineering Design I.....	0	6

(Optional.)

Mechanical Engineering of Power Plants.....	3	3
Graphic Statics.....	9	0
Engineering Design II.....	0	6
Engineering Design III.....	0	9
Metallurgical Laboratory I.....	3	3
Metallurgical Laboratory II.....	6	6
Applied Geology I.....	3	3
Applied Geology II.....	6	6
Journal Club.....	3	3

SECOND SEMESTER.

(Required Work.)

	First term Hours per week.	Second term. Hours per week.
Mining	3	3
Metallurgy of Lead and Zinc....	3	3
Engineering Construction.....	2	2

Mining and Ore Dressing Excursion, two weeks.

(Optional.)

Ore Dressing.....	2	2
Metallurgy Laboratory.....	3	3
Ore Dressing Laboratory.....	3	3
Mechanical Engineering of Power Plants	3	3
Engineering Design I.....	3	3
Engineering Design II.....	6	6
Engineering Design III.....	9	9
Applied Geology II.....	6	6
Journal Club.....	3	3

ENGLISH

G. C. STALEY.

English Composition.—This is a course in the principles and practice of English composition. Lectures are given on the whole composition, paragraph and sentence; weekly themes and daily paragraphs are required; notes are taken on assigned readings. The work is intended to supplement the usual high school courses in composition. Instead of dealing with figures of speech and other rhetorical devices, however, it has to do more with the outline, unity, coherence, and emphasis, as applied to exposition and argumentation.

Freshman, first semester, two hours per week.

English—Technical Prose.—This is a continuation of the first course. Studies are made in the structure of modern prose; critiques and model paragraphs are written; lectures are given on words. Training in business correspondence is also given, and special studies made in technical vocabulary

Freshman, second semester, two hours per week.

MATHEMATICS

PROFESSOR CRAVEN, G. C. STALEY.

Algebra.—A short preliminary course is first given, designed to drill the student in the fundamental operations and in the statement and solution of problems. The following topics constitute the chief items for the term's work: Indeterminate coefficients; theory and use of logarithms; limits; introduction to derivatives; binomial and logarithmic equations; solution of numerical equations.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and oblique triangles; practical problems. The solution of the right and oblique angled spherical triangles is developed and practical application is made to surveying and mensuration. The text book used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—In this course a systematic study is made of the following: The point and straight line in a plane; different systems of coordinates; conic sections; discussion of the general equation of the second degree with two variables; higher plane curves; the point and straight line in space; curved surfaces and surfaces of revolution. The text used is Wentworth's Analytic Geometry.

Freshman, second semester, three hours per week.

Calculus.—Among the topics studied in this course may be mentioned: Differentiations, Taylor's theorem; indeterminate forms; maximum and minimum; tangents, normals, and asymptotes; curvature and radius of curvature; integration; rectification of curves; areas; volumes; center of mass; moment of inertia. Application is made to numerous problems in mechanics during the latter part of the lectures. The text being presented in the form of lectures. The text book used is Differential and Integral Calculus, by Taylor.

Sophomore, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY

PROFESSOR LINCOLN.

Crystallography.—The course in Crystallography consists of a short series of lectures supplemented by laboratory and drafting practice. One afternoon each week is devoted to crystal drawing and another to the examination of natural crystals and models. The aim is to familiarize the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. Moses and Parsons' "Elements of Mineralogy, Crystallography and Blowpipe Analysis" is used as a text book both in this and in the succeeding courses in mineralogy.

Sophomore, first semester, first term, eight hours per week.

Blowpipe Analysis.—The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the course is to teach the student to use the blowpipe and to make other chemical tests of importance in mineralogy. This course is introductory to that in determinative mineralogy.

Sophomore, first semester, second term, eight hours per week.

Descriptive Mineralogy.—The course consists of lectures, tests and laboratory work, and is a companion course to that in Determinative Mineralogy. Crystallography is a prerequisite. The introductory lectures take up the characters of minerals and the occurrence and origin of minerals, then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by assigning time for examination of the student, lecture, exhibition specimens of the minerals studied and requiring the identification of some of these specimens in each test. By this means the student learns to identify typical specimens by their external appearance alone. The object of the

course as a whole is to make the student thoroughly familiar with the appearances, properties, associations, and uses of the economically important minerals and to give him some insight into the practical and scientific problems connected with mineralogy.

Sophomore, second semester, four hours per week.

Determinative Mineralogy.—This course consists entirely of laboratory work and thus supplements the contemporary course in Descriptive Mineralogy. Blowpipe Analysis is a prerequisite. The operations and principles learned in the earlier course are in this course practically applied to the determination of mineral species. The aim of the exercises is to train the student to determine minerals with accuracy and rapidity by means of physical and chemical tests.

General Geology.—The course in General Geology embraces lectures, recitations and laboratory work. The lectures and recitations cover the principles of dynamical, structural, and physiographical geology. The laboratory work includes practice in the identification of rocks and exercises with topographical maps. Chamberlin and Salisbury's "College Geology" is used as a text book. The course is designed to render the student familiar with the general principles of geology and the methods employed in solving geological problems.

Junior, first semester, eight hours per week.

Historical Geology.—This course consists of one lecture and two laboratory hours weekly. The course in General Geology is a prerequisite. The lectures take up the history of the earth, discussing changes of level between land and sea, of topography, of climate, and of the successive groups of animals and plants which have lived upon the globe. Special attention is paid to the geological history of Montana. The laboratory work includes a study of those fossils which are the most abundant and the most characteristic indices of the ages of different strata, the identification of unknown material and the working out of practical problems through the aid of fossils.

Junior, second semester, three hours per week.

Petrography.—This course consists of two lectures and two afternoons in the laboratory weekly for one semester. General Geology is a prerequisite. The course is introduced by a review of the principles of optics, after which optical mineralogy is studied, using Johannsen's "Key to the Determination of Rock-Forming Minerals" as a text. The student becomes familiar with the use of the petrographical microscope

and is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is taught to examine these hand specimens at the same time with slides. This course affords the student an opportunity to become thoroughly familiar with the macroscopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in Applied Geology.

Junior, second semester, six hours per week.

Field Geology.—The course in Field Geology consists in the detailed study of geology of a selected area. Historical Geology is a prerequisite. Instruction is given in observing, recording and interpreting geological phenomena, and in the preparation of geological maps and sections. Upon completion of the field work, each student is required to prepare an accurate and detailed geological report on the area investigated.

Senior, first semester, two weeks in field and three hours per week in laboratory.

Economic Geology.—The course in Economic Geology consists of lectures and drafting exercises. Structural Geology is a prerequisite. The lectures treat of the methods of occurrence, geological relations, origin and commercial value of the more important economic deposits of the world. Five lectures weekly for one semester are devoted to the subject. Stress is laid upon the ore deposits of the United States and specially upon those of Montana. Ries' "Economic Geology of the United States" is used as a text book, strongly supplemented by lecture notes.

Senior, first semester, five hours per week.

Applied Geology I.—Mines and other points of geological interest in the neighborhood of Butte are visited and the facts observed set down in a note book. The data thus obtained are used in working out practical problems of a geological nature.

Optional. Senior, first semester, three hours per week.

Applied Geology II.—A problem in which geology plays an important part is worked out in detail and a thesis written upon it. As an example of the character of work required by this course may be cited the geological and economic

examination of a mine or mining district. When a problem of this nature is undertaken, it will usually be found distinctly advantageous to reserve one afternoon a week in addition to the time required for the course proper, this extra afternoon to be devoted to the solution of some problem in designing or metallurgy connected with the mine or district examined.

Optional. Senior, first and second semesters, six hours per week.

Journal Club.—One afternoon each week is devoted to the discussion of articles of special interest occurring in the current geological, mining and metallurgical journals.

Optional. Senior, three hours per week.

CHEMISTRY

PROFESSOR HARTZELL

General Chemistry.—The subject of general chemistry is presented through lectures and text books. The object of the course is to develop the underlying principles of chemistry as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements, the work is also copiously illustrated with experiments conducted by the instructor. It is necessary that the student should take full notes on the lectures, which are designed to aid and direct the laboratory work of the same semester. Text book, Remsen's College Chemistry.

Freshman, first semester, three hours per week.

General Chemistry, Laboratory.—The laboratory course in general chemistry consists in performing a large number of experiments by the students at individual desks. Aside from becoming proficient in the use of apparatus, the student becomes familiar with the different acids, bases and salts, their reactions and relations with each other. It is a part of the work to keep a neat notebook in which are recorded the reactions and statements of the principles involved in each experiment.

Freshman, first semester, six hours per week.

Qualitative Analysis.—The course in qualitative analysis is designed to instruct the students in the general schemes of analysis by which the different metals are detected and separated from each other. The problem of isolating and identifying the acid radicals is also a part of the course. The accompanying lectures give a general outline of the schemes of separations and deal with the merits and difficulties of each,

finally pointing out the best method to be used by the mining engineer. The essential element of writing and balancing chemical equations is made a part of the drill work of the class. During the last part of the course the class is introduced to the subject of stoichiometry. The text book used is Prescott and Johnston's "Qualitative Analysis."

Freshman, second semester, three classroom hours and nine laboratory hours per week.

Quantitative Analysis.—The course in quantitative analysis embraces a study of such analyses as the mining engineer meets in practicing his profession in the laboratories of smelters and mine plants. The main object in view is to develop the ability of the student to do this work with the accuracy and the rapidity required in practice, so that the student who completes the course need have no hesitancy to accept a position of this character.

Among the analyses performed may be mentioned the analysis of limestone, dolomites, feldspars, ores of iron, manganese, lead, zinc, arsenic, copper, etc. Analyses are made of mattes, flue dust, concentrates, calcines, and pig-iron. During the course some time is spent on acidimetry and alkalimetry. The laboratory work is performed by the students at individual desks, where the best appliances and modern conveniences are at hand. The classroom work consists of discussions and quizzes on the theory of the laboratory work.

Sophomore, first semester, two hours classroom and nine hours laboratory work per week; second semester, ten hours per week.

METALLURGY

PROFESSOR BOWMAN.

Introduction to Metallurgy.—The study of metallurgy begins with lectures and recitations on the fundamental principles of the art. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, product of combustion, etc., are studied. The various fuel, solid, liquid, and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast, reverberatory, muffle, and electric, used in metallurgical operations

are studied. In connection with this the methods for utilizing waste heat are discussed. The efficiency of the various types of furnaces are calculated. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated. A few weeks are devoted at the end of the semester to the metallurgy of iron, text book, Robert-Austin "Introduction of Metallurgy;" L. S. Austin's "Metallurgy of the Common Methods."

Junior, first semester, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of the smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining matte in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations studied is required of each student.

Junior, second semester, three hours per week.

Metallurgy of Gold and Silver.—The first semester of the senior year is devoted to the metallurgy of gold and silver from lectures and text books. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The older metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiviation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student of the plant visited.

Senior, first semester, three hours per week.

Metallurgy of Lead and Zinc.—The subject of the metallurgy of lead is taken up the second semester of the senior year. The subject is presented in the form of lecture and text book work. The processes of roasting, pot-roasting and smelting of lead ores are discussed, as well as the refining of lead bullion by the Parkes and Pattison processes and by the Betts electrolytic process.

The metallurgy of zinc is treated more briefly and is followed by a short discussion of the methods of reducing aluminum, nickel, etc.

The lecture room work on lead and zinc is followed by metallurgical excursions to the lead smelter at Helena or the lead smelters at Salt Lake City and notes and reports required of the students covering the examinations made at these works.

Senior, second semester, three hours per week.

Assaying.—The subject is presented in the form of lectures with reference to text books. The practical work consists of the fire assaying of gold, silver and lead in all varieties of crude ores and smelter products, such as copper and lead slags, copper and lead matte, copper and lead bullion, lead dross and speiss, calcines, flue dust, tailings, etc.

The laboratory is fitted with the most modern appliances and it is a part of the aim of the course to give the student a thorough drill in accuracy and rapidity.

Junior, first semester, first term, twelve hours per week.

Gas and Fuel Analysis.—The student is taught to use the standard types of gas analysis apparatus and determine the commoner and more important constituents of furnace and smelter flue gases. The latter part of the course is taken up with the proximate analysis of coals and cokes and the determination of their heating power by means of the calorimeter.

Junior, first semester, second term, three hours per week.

Metallurgical Laboratory.—The work consists of a series of experiments illustrating various metallurgical processes. The changes which an ore undergoes when subjected to oxidizing or chloridizing roasting are investigated, as well as sulphatizing reactions. Some time is devoted to the measurement of high temperatures and a study of the melting points of silicates and slags. The electrolytic refining of copper is studied.

Junior, second semester, three hours per week.

Metallurgical Laboratory.—The laboratory work of the junior year is continued with practice in the methods of ore

testing in the laboratory. Concentration, cyanide and chlorination tests are made with small quantities of ores, the tests being so made that reliable conclusions can be drawn as to what will take place on a large scale. Determinations are made on the proportions of sand and slime produced in crushing ores, the most economical size to crush to, most economical strength of solution to use, cyanide consumption, etc.

Senior, first semester, three or six hours per week.

Ore Testing Laboratory.—The laboratory work of the senior year consists of tests on bulk parcels of ore in order to determine the most suitable methods of treatment. Experiments are also made with a view of testing improved or new processes of extracting metals from their ores. The ore testing building is equipped with crushing and concentrating plant, cyanide and chlorination plant, in which lots of several tons of ore at a time can be treated. There is also a wedge roasting furnace, a Bruckner calciner and a reverberatory furnace. The work at the metallurgical plant is checked by sampling and assaying.

Senior, second semester, three or six hours per week.

MECHANICS

PROFESSOR CRAVEN.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the

steam engine and to the transmission of energy by means of compressed air is considered. The text books used are: Elements of Mechanics, by Merriman; Elementary Lessons in Heat, by Tillman.

Sophomore, first semester, five hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met with in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Electrical Catechism, by Shepardson, is used as a text book.

Sophomore, second semester, six hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc. Merriman's Mechanics of Materials is used as a text book.

Junior, first semester, three hours per week; second semester, two hours per week.

Applied Mechanics.—It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as

screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, supports for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application to mining machinery is found in the catalogues furnished us by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte.

Junior, first semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the west. The course is introduced with a brief review of hydraulics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's *Treatise on Hydraulics* is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course of systematic study is made of the mechanism of engines, non-condensing, condensing, simple, and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power houses are also made a part of this course.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr. The text book used is *Steam Engines and Boilers*, by Kenneally.

Senior, first semester, three hours per week.

Power Transmission.—The extensive use of electrical

power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmission, power transmission by continuous current, some properties of alternating circuits, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening,—a roof, bridge, or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due to a locomotive, also stresses due to wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. *Steel Mill Buildings*, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Senior, first semester, first term, nine hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; constructions of retaining walls, foundations dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is *Ketchum's Steel Mill Buildings*.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN

PROFESSOR CRAVEN, MR. ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The following list is recommended; other minor necessities may be supplied as suggested later by the instructor: One 5½-inch compass, one 3¼-inch bow divider, one 3¼-inch bow pencil, one 3¼-inch bow pen, one 5-inch ruling pen, one 8-inch 30°x60° amber triangle, one 8-inch 45°x45° amber triangle, one 12-inch architect's triangular scale, one T-square—36-inch blade, one drawing board 24x32 inches.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshman, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subjects laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, with the conventions used in mine and geological maps, and many other use-

ful items used in mining. The text books are the same as used in the first course.

Freshman, second semester, six hours per week.

Machine Design.—This course is an application of the material presented in the second course in applied mechanics. The object is to give instruction in machine drawing so that repair parts for hoists, crushers, rolls, stamps, etc., may be correctly designed and represented. Attention is given to conventions, sections, correct lettering, and dimensioning. The problems are given entirely by dictation. Machine Design, by Low and Bevis, and Kent's Mechanical Engineer's Hand Book are used as reference books. Several copies of these volumes are to be found on the tables of the drawing room.

Junior, first semester, second term, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING

PROFESSOR SIMONS, MR. ADAMI.

Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requiring a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, four hours per week.

Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating quantities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, three hours per week.

Surveying.—A four weeks' trip in the field by the freshmen, at the end of the second freshmen semester. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes,

maps, profiles, calculation sheets, etc.: Exercises in pacing, ranging and chaining and solution of geometrical problems with the chain. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth, and deflection. Problems in public land surveying in accordance with Manual of Instruction to U. S. Deputy Surveyors. Official survey of mining claims in application for U. S. patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to U. S. Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Determination of elevations by aneroid barometer. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Freshman, summer course of four weeks.

Surveying.—A four weeks' trip in the field by the Sophomores at the end of the second Sophomore semester. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shaft by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the coordinates for each station N., S., E. and W. of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods.

Sophomore, summer course of four weeks.

Topographical Drawing.—This subject follows the practical field surveying of the freshman class. The work consists in platting on a convenient scale the surveys executed in the field. During the preparation of the various topo-

graphical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders, and north points, and general neatness in execution.

Sophomore, second semester, three hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN

PROFESSOR SIMONS.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines, where mining operations are observed.

Junior, second semester, two hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, first semester, second term, two hours per week.

Mining.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, three hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Description of the construction and operation of typical crushing machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

Seniors, second semester, two hours per week.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, second semester, six hours per week.

Mining Engineering Design.—I. Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always

present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

Mining Engineering Design.—II. and III. are along the same lines as course I., the work in the higher courses being more extensive and requiring six and nine hours of work per week respectively, for the second term of the first semester and for both terms of the second semester.

Senior, all year, six or nine hours per week.

SKETCH CLUB.

The name of "Sketch Club" has been applied to the classes which go on trips during the second semester to visit the mines and smelters of the city. The students are accompanied by at least two professors, who point out items of interest and assist the students in sketching standard engineering devices which may be of use in after practice. The students are taught to observe operations with an engineering interest, which is a most beneficial habit to acquire.

Senior, second semester, three hours per week.

MINING LAW

E. B. HOWELL

A short course of lectures on mining law, particularly in regard to the rights of prospectors, the apex rights, water rights, the location of placer and lode claims, and the lateral rights of the locator as determined under the laws of the United States and the State of Montana. The course consists of fifteen lectures and is required of juniors and seniors. The course is given every other year. Will be given 1910-1912.

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the school. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. Fortunately it does not demand an extensive equipment. At the School of Mines it is furnished merely with a large recitation and lecture room on the second floor, abundantly supplied with blackboard space, and with slate, terrestrial and celestial globes, some simple models and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY AND METALLURGY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department,

together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qualitative and quantitative analysis, one for metallurgy, and two professors' laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of students in the laboratories. These balances are placed on stands which rest on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The professors' laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the students in the laboratories and all check analysis on the students' work are made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with

pneumatic trough, gas, water, hydrogen and oxygen blast and a direct alternating current of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a buckboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold, and silver ores, together with mattes, both copper and lead, slag, flue-dusts, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state. Each student is required to collect, crush, grind and buck five twenty-five pound samples in the assay course, and to cut down and assay these samples.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be simply calcined, or a

chlorination roast can be made by the hyposulphite treatment. There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

A very complete set of the products of the metallurgical processes in use at the Boston & Montana smelter at Great Falls is installed in one of the Mineralogical Museum cases; this includes an exhibit of electrolytic slime together with ingots showing the exact amount of copper, silver and gold recovered from a definite amount of this slime. There are also several views of the interior of the smelter and adjoining properties, as well as a flow sheet of the concentrator connected with the plant.

The Butte Reduction Works is represented by a large number of its metallurgical products, including concentrates, tailings, mattes, sulphur-coated ore, etc. The products of the Washoe smelter are also present including samples of the copper cakes and anodes produced at Anaconda.

In addition to the mine models there are two metal-

lurgical models in the Mineralogical Museum; one is a model of the Holthoff-Wethey calcining furnace, as in use at the Butte Reduction Works, showing the device by means of which the rails and wheels supporting the harrows are kept outside of the furnace proper; the other is a model of the Pratt centrifugal ore sizer for sizing ore before it is run over Wilfley tables.

Several appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, of the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls, and of various mines and mills about the State. In addition, there is a large drawing to illustrate the method of sampling in use at the Washoe Sampling Works, and several drawings of the coal washery of the Cottonwood Coal Company.

The new ore testing and metallurgical laboratory occupies a separate building, 77 by 70 feet, half of which is devoted to metallurgical work. This contains complete cyanide and chlorination plants, a Wedge roasting furnace, a Bruckner calciner, a reverberatory furnace and other accessory appliances for metallurgical investigations capable of dealing with several tons of ore at a time.

Storage bins for ores, slags, etc., are provided and an adjoining room is being fitted up for electro metallurgical work, pyrometry, etc.

DEPARTMENT OF MINING AND ORE DRESSING.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy four large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing boards are also provided. A large collection of drawings furnished by various manufacturing

companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following instruments have been provided: Six engineering transits; one from Buff and Buff, one from C. L. Berger & Sons, three from Gurley, and one from Keuffel and Esser. Four levels—one from Buff, one from Gurley, one from Keuffel and Esser and one from Berger. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plummets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight inch by twelve inch Dodge crusher, two sets of twelve and one-half inch by twelve inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for

dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs, Wilfley table, hydraulic classifiers, automatic feeder, etc. for testing ore in quantities up to four hundred pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these

manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very instructive section through part of the Great Falls concentrator, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The Department of Geology and Mineralogy occupies eight rooms and part of three others. On the first floor is the geological museum with its overflow accommodated in the adjoining lecture room; on the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the mineralogical museum, the thin-section lathe room, the dark room and the storage

room, while a collection of geological mine models occupies part of the drafting room.

The collections of minerals, of rocks, of fossils, of ore, and country-rocks, belonging to the department have each been subjected to a threefold division into museum specimens and student specimens. The student collections are placed in drawers where they are accessible to the students at all times; the lecture specimens are kept in the office, where they may only be examined in the presence of an instructor; and the museum collections, which consist of the rarer, the larger and the more delicate specimens, are kept under the glass where they may be seen but not handled.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. These rooms and their contents will now be described, with the omission of certain special apparatus and collections which are more consistently described later. The office is twenty-two feet long by twenty feet wide. It is fitted with desks and tables for the convenience of officers of the department, with cabinets for the various lecture collections and with book-cases for the departmental library. The lecture room is provided with large blackboards and furnished with a suitable desk and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. The dark room on the third floor contains apparatus and chemicals for photographic work. The storage room on the same floor contains materials for the museums or class rooms which has not yet been prepared for study or exhibition.

Mineralogy.—The large set of crystals included in the

lecture collection of minerals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercises. In addition to these real crystals, three series of crystal models are available, two of wood and one of celluloid. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory. The stereographic projection of models and crystals is performed in the mineralogical museum.

The Mineralogical Museum contains the museum collection of minerals. This has been separated into two parts; a systematic collection arranged according to Dana, and an economic collection arranged according to Moses and Parsons. A collection of one hundred and sixty gold crystals presented to the School by Mr. C. W. Clark is kept on exhibition in the library. The museum is thirty-one feet square and only a third of the floor space is occupied by the six cases of minerals. The remainder of the room is at present used as a drafting room.

The Mineralogical Laboratory is thirty-one feet square and contains six laboratory tables capable of accommodating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains ninety-one specimens illustrating the physical characters of minerals.

In another corner stands a cabinet containing two hundred and eighty-eight mineral species and varieties arranged according to Moses and Parsons. Pycnometers, Westphal balance, Plattner scales, burettes, agate mortars, and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here will also be found a case of chemical and

mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks.

Geology.—The Geological Museum occupies a room thirty-one feet square. Four plate glass cases belonging to the museum have been placed in an adjoining lecture room. The museum has tables arranged next the windows on three sides and the remainder of the room is occupied by cases and cabinets.

For laboratory work with rocks the department is equipped with over nine hundred specimens arranged in two large cabinets, each containing thirty drawers. Glass show cases surmount these cabinets. In one of these is a series of rocks illustrating the more important structures, and in the other a collection of rock specimens from the Yellowstone National Park. Over two hundred duplicate rock specimens are kept in drawers in the office; and wooden models for the lecture demonstration of different types of faulting are also kept there.

The laboratory exercises with maps are conducted on the tables in the museum. Two large cabinets, containing geologic and topographic maps respectively, furnish the material for this work. These cabinets are kept in the School Library.

Historical Geology laboratory exercises are also carried on in the museum. One case is filled with the larger and the more perfect fossils.

Although laboratory work in economic geology is not required in the course at the School, nevertheless a student collection of specimens of economic interest has been placed in the geological museum and is utilized in connection with the course in economic geology. Like the student rock collection, it occupies sixty drawers, and above it in glass cases have been placed some of the more

interesting economic specimens. There are ten other show cases containing specimens belonging to the museum economic collection. The collection embraces specimens of copper ores from all the large mines of Butte, comprising average and picked samples, samples which are mixtures of several ore-minerals and those showing massive or crystalline varieties of a single mineral, specimens of the country rocks, mineral veins and slickensided samples of ore. In addition to the collection of Butte ores, there is a large collection of specimens of coal and of gold, silver, copper and lead ores from the various mining districts of Montana. Besides this, there are samples of graphite, coke, molybdenite, scheelite, corundum, limonite, onyx, clay, gypsum, mineral paint, and oil from various parts of the State. Whenever possible these specimens are placed beside samples from other states for purpose of comparison. A fine set of ores, minerals and country rocks from the Lake Superior iron ranges has been donated by Mr. F. A. Glass, a former student. Mr. H. Lipson Hancock, manager of the Wallaroo and Moonta Mines, has recently donated to the School a beautiful set of minerals from the Australian mines, which are also on exhibition in one of these show cases. Upon the wall of the geological museum hangs a colored diagram representing an "Ideal Section of a Butte Copper Vein." This was constructed by the Geological Department of the Anaconda Copper Mining Company and has been reproduced in print several times. The lecture room walls are hung with diagrams showing the relative production of various metals in Montana and other states, and a map made at the School showing all the important mineral districts of Montana. In one of the drafting rooms there is a fine set of geological mine models.

For the work in Field Geology, the department is

equipped with a transit, a level, six Brunton compasses, two aneroid barometers, geological hammers, tapes, a camera, Attwood clinometer, Abney mine level and a Keuffel and Esser compass and clinometer. A complete camp outfit is available for the use of department.

Petrography.—In the Geological Museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type made by Leitz in Wetzlar. These microscopes are all provided with the necessary attachments for ordinary petrographic work, and two of them, one Leitz and one Nachet, are of larger size than the others and are equipped with accessories for research work. The School has just purchased from Fuess a very fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the museum contains two hundred and fifty-eight oriental slides of minerals, six hundred and sixty-seven thin sections of rocks, and seventy-four slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are almost all represented by hand specimens in the student collection of rocks (which is kept in this museum and has already been described), so that the student may observe the microscopic character so that the student may observe the macroscopic character studying. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a col-

lection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall-case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a wire and also with a wheel, both for cutting slices. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes. Wheatstone bridges, galvanometers, batteries, keys, etc.

The engine and dynamo room is located in the basement of the building; there is installed here a gas engine of fifteen horsepower, from which is belted a line shaft driving direct and alternating current dynamos. A switch-board connects these machines with lines running to vari-

ous parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. The requisite voltmeters and ammeters for both alternating and direct current, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression and shearing tests. The accessories consist of the following: One Olson compression micrometer especially designed for measuring the compression of stone cubes and other building material; one Olson improved deflection instrument for measuring the deflection of beams subjected to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough

study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

Charlotte Russell, Librarian.

The number of publications in the library, departmental and others, is nearly 4,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; and Engineering Corps. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, and geological magazines, are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers.

A valuable collection of the standard works and treatises on the various branches of science taught in technical schools has been secured by donation.

MAGAZINES.

The following technical and general magazines and periodicals will be found in the library, where they may be freely consulted by the students:

- American Journal of Science.
- Anaconda Standard.
- Bulletin of the Geological Society of America.
- Bulletin of the International Bureau of American Republics.
- Cassier's Magazine.
- The Century.
- Chemical News.
- Collier's Weekly.
- Engineering Magazine.
- Engineering and Mining Journal.
- Engineering News.
- Electrical Age.
- Electrical World.
- Everybody's Magazine.
- Harper's Monthly.
- Harper's Weekly.
- Iron Age.
- Journal of the American Chemical Society.
- Journal of the Association of Engineering Societies.
- Journal of Geology.
- Journal of Geography.
- Journal of the Geological Society of Tokio.
- Life.
- Machinery (Engineering Edition).
- McClure's Magazine.
- Mineral Industry.
- Metallurgical and Chemical Engineering.
- Mines and Minerals.
- Mining and Scientific Press.
- Mining Magazine.

Mining Review.

Mining Science.

Mining World.

National Geographic Magazine.

Nature.

Neues Jahrbuch fur Geologie, Mineralogie, etc.

Outlook.

Outing Magazine.

Popular Science Monthly.

Review of Reviews.

Salt Lake Mining Review.

Scribner's Magazine.

School of Mines Quarterly.

Technical World.

Transactions of the American Institute of Mining Engineers.

Tschermak's Mineralogische and Petrographische Mittheilungen.

World's Work.

The following newspapers are kindly furnished by their publishers free of charge:

The Ravalli Democrat (weekly), Hamilton.

Great Falls Leader (daily), Great Falls.

The Missoulian (daily), Missoula.

The Tribune-Review (weekly), Butte.

GENERAL INFORMATION.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given to this locality such publicity that no one now needs to be told of its leading position in the mining world.

Following a long period in which its mineral product, though larger than that of any other field, was kept far below its capacity by reason of conflict of title to mining ground, a settlement has been effected which will permanently remove all such restriction in its output. New life has been infused, new mines located, and such aggregations of capital have been enlisted as promise a vast increase in its production for a generation to come. With this increase in production, there has come a largely increased demand for copper, and a consequent advance in prices, that must for some years to come make the mining of the red metal in Butte one of the most profitable industries of the world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city must be enlarged to treat the enlarged product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment

of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with all the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the very extensive mining and metallurgical plants in the vicinity of the school.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter; the opportunity is here presented for daily observation of works, the development and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the school under the guidance of their instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the freshmen spend four weeks of their summer vacation time in camp, where they are given fifty hours per week

in learning the use of surveying instruments, and in such exercises as are detailed on page 30. The sophomores, in like manner, spend four weeks of their summer vacation in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in some one of the interesting geological fields of this and adjoining states.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical opportunity of visiting these mining plants and observing be overestimated.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the student, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order. The balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR

General Chemistry and Qualitative Analysis.....	\$15.00
Surveying	10.00

SOPHOMORE YEAR

Mine surveying	10.00
Quantitative Analysis.....	\$15.00
Mineralogy	10.00
Deposit for Platinum Ware.....	20.00

JUNIOR YEAR

Metallurgy and Assaying.....	\$10.00
Petrography	10.00

SENIOR YEAR

Metallurgy	\$10.00
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When the breakage exceeds the deposit the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as are approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

LIST OF STUDENTS

SENIOR CLASS.

Grunert, August.....	Butte, Montana
Jensen, Walter H.....	Great Falls, Montana
Stuewe, William, Jr.....	Helena, Montana

JUNIOR CLASS.

Clinch, Ralph S.....	Butte, Montana
Dailey, R. N. A.....	Great Falls, Montana
Kyle, Walter A.....	Butte, Montana
McElvenny, Linden T.....	Butte, Montana
Murphy, James K.....	Butte, Montana
Pilger, Theodore.....	Butte, Montana
Roach, James C.....	Butte, Montana
Sultzter, H. D.....	Butte, Montana
Tout, Charles.....	Butte, Montana
Zentner, Arthur.....	Butte, Montana

SOPHOMORE CLASS.

Andrew, John T.....	Butte, Montana
Christian, O. B.....	Butte, Montana
Clinch, W. D.....	Butte, Montana
Cohen, Jesse.....	Anaconda, Montana
Cullity, Emmett.....	Berkeley, California
Fowler, George M.....	Lewistown, Montana
Gervais, Paul.....	Anaconda, Montana
Gidel, Murl.....	Butte, Montana
Giovanetti, Ettore.....	Butte, Montana
Grupe, Charles.....	Vancouver, B. C.
Newton, Lucian.....	Butte, Montana
Pierse, Edwin A.....	Great Falls, Montana
Tilton, Howard.....	Butte, Montana
Williams, Paul.....	Butte, Montana

FRESHMAN CLASS.

Anderson, Charles.....	Anaconda, Montana
Crittenden, Zar T.....	Butte, Montana
Cullity, Edwin.....	Berkeley, California
Hanson, Wilbur.....	Butte, Montana
Kemper, David.....	Butte, Montana
Kenck, Max W.....	Butte, Montana
McAuliffe, Walter.....	Butte, Montana
McCoole, Edward.....	Butte, Montana
Manwaring, J. H.....	Ann Arbor, Michigan
Olsen, Charles.....	Butte, Montana
Osenburg, Rudolph.....	Butte, Montana
Reid, Milton.....	Anaconda, Montana
Simons, Walter.....	Butte, Montana

SPECIAL STUDENTS.

Cooke, Hamilton, Jr.....	St. Louis, Mo.
Corr, F. R.....	Butte, Montana
Cullerton, M. J.....	Butte, Montana
Crangle, E. J.....	Butte, Montana
Emery, John A.....	Butte, Montana
McBride, Reid.....	Butte, Montana
O'Connor, Charles H.....	Seattle Washington
Peterson, P. E.....	Butte, Montana
Silverman, Herbert.....	Butte, Montana
Wild, Edgar.....	Butte, Montana

REGISTER OF ALUMNI

CLASS 1903.

Bender, Louis V.....Anaconda, Montana
Supt. Blast Furnaces, Anaconda Copper Mining Co.

CLASS 1904.

Balmforth, Alfred J.....San Antonio de la Huerta, Sonora, Mex.
Duling, Fred J.....Los Angeles, California
Supt. Pacific American Development Co.

Ireland, Arthur J.....Helena, Montana
Kuphal, Henry E.....Missoula, Montana
Mining Engineer, "Kuphal & Bonner, Min'g and Civil Engrs."
MacRae, Lachlan D.....Santa Eulalia, Chihuahua, Mexico
Engineer, San Toy Mining Co.

Stevenson, Isabel Little.....Berlin, Pennsylvania
McGee, John..Greenwater, via Death Valley, P. O. California
Pauly, P. L.....Basin, Montana
Supt. Montana Mineral Land Development Co.

Reese, Clara Clark.....Denver, Colorado
Tallant, H. S.....Butte, Montana
Mining Engineer.

CLASS 1905.

Archibald, George.....Helena, Montana
Mineral Inspector, G. F. O.

Brinton, O. F.....Tooele, Utah
Engineer, International Smelting & Refining Co.

Corey, Clarence R.....Seattle, Washington
Instructor in Metallurgy, University of Washington.

Duthie, John M.....Libby, Montana
Mining and Civil Engineer.

Elford, Basil.....Tonopah, Nevada
Assayer, Tonopah-Belmont Mining Co.

Mackel, Louis.....Butte, Montana
Mining Engineer, B. & M. Con. M. & S. Co.

Pratt, Paul D.....Libby, Montana
Mining and Civil Engineer.

Stevenson, Leon Clark.....Berlin, Pennsylvania
Engineer and Chemist for Brothers Valley Coal Co.

Van Gundy, Jay.....Wardner, Idaho
Mining Engineer, Last Chance Mine.

CLASS 1906.

Dugan, John F.....Butte, Montana
Engineer, Anaconda Copper Mining Company.

Feeney, Charles W.....	Butte, Montana
Engineer, Armstead Railroad.	
Geiser, Herbert S.....	Cerro de Pasco, Peru
Chemist, Cerro de Pasco Mining Company.	
Johns, John W.....	Wicks, Montana
Engineer, Corbin Copper Co.	
Kane, Louis N.....	Butte, Montana
Foreman, Berkeley Mine.	
Warfield, Hershel J.....	Butte, Montana
Mining Engineer, B. & M. Co.	
Wilson, Bert T.....	Wardner, Idaho
Mining Engineer and Transit Man, Federal Min'g & S. Co.	
Young, Siegfried A.....	Hereford, Arizona
Supt. Princeton C. M. & S. Co.	
Young, Arthur B.....	Wardner, Idaho
Engineer, Federal Mining & Smelting Co.	

CLASS 1907.

Adami, Aruthur E.....	Butte, Montana
Instructor Survey'g & Drawing, Mont. State School of Mines.	
Bovett, Clifford A.....	Mason, Nevada
Engineer, Mason Valley Gold Mining Co.	
McCracken, Ralston H.....	Cerro de Pasco, Peru
Shift Boss, Esperanza Mine.	
Reardon, Daniel.....	Butte, Montana
Draftsman, Linke & Haire, Architects.	
Schafer, William A.....	Rawhide, Nevada
Engineer, Rawhide Queen Mines Co.	
Engineer, Rawhide Coalition Mines Co.	

CLASS 1908.

Bowden, Malcolm.....	Butte, Montana
Sampler-Boss Trammer, B. & M. Co.	
Ellis, Willis H.....	Butte, Montana
Foote, Frank A.....	Ray, Arizona
Sampler, Ray Consolidated Copper Co.	
Ketcham, Samuel H.....	Stevensville, Montana
Bitter Root Irrigation Company.	
Lomas, Percy.....	Ray, Arizona
Ray Consolidated Mining Co.	
Lowry, Thomas M.....	Great Falls, Montana
Engineer, Missouri River Power Company.	
McLaughlin, William D.....	Butte, Montana
Surveyor, Red Metal Mining Company.	
Meiklejohn, Archie B.....	Butte, Montana
Boss Trammer, Red Metal Mining Company.	
O'Brien, Albert.....	Butte, Montana
Mining Engineer, with Barker & Wilson.	
Patten, Earle.....	Butte, Montana
Assayer, B. & M. Company.	
Proctor, Israel O. Jr.....	Butte, Montana
Field Engineer, Globe Mines Exploration Company.	
Proctor, Merton D.....	Butte, Montana
Red Metal Mining Co.	

Schiffner, Otto E.....	Butte, Montana
Draughtsman, East Butte Copper Mining Co.	
Villars, Jesse R.....	Great Falls, Montana
Civil and Mining Engineer, U. S. Mineral Surveyor.	
Walton, Lee M.....	Ray, Arizona
Engineer, Ray Consolidated Mining Co.	
Wren, Andrew A.....	Ray, Arizona
Sampler, Ray Consolidated.	

CLASS 1909.

Brulo, William.....	Helena, Montana
Evans, James.....	Butte, Montana
Engineer, Butte & Superior Copper Mining Co.	
Gilham, Ralph E.....	Radersburg, Montana
Engineer, Keating Gold Mining Company.	
Haines, Peter.....	Anaconda, Montana
Assistant in Testing Department, Washoe Smelter.	
Johnstone, J. Clark.....	Billings, Montana
Asst. Engineer, Eastern Montana Electric Railway Co.	
Kane, Edward P.....	Butte, Montana
Engineer, Anaconda Copper Mining Co.	
Kirby, Kenneth P.....	Anaconda, Montana
Testing Department, Washoe Smelter.	
Loughran, Michael.....	Butte, Montana
Malloy, Edward F.....	Great Falls, Montana
Mining Engineer.	
Peters, Ira B.....	Bingham Canyon, Utah
Engineer, Bingham-New Haven Mining Co.	
Stockett, Norman A.....	Chicago, Illinois
Draughtsman, Link Belt Company.	
Weigenstein, Henry J.....	Butte, Montana
Mine Superintendent, Tramway Mine.	
Young, William A.....	Gilt Edge, Montana
Engineer, Gold Leaf Mining Co.	

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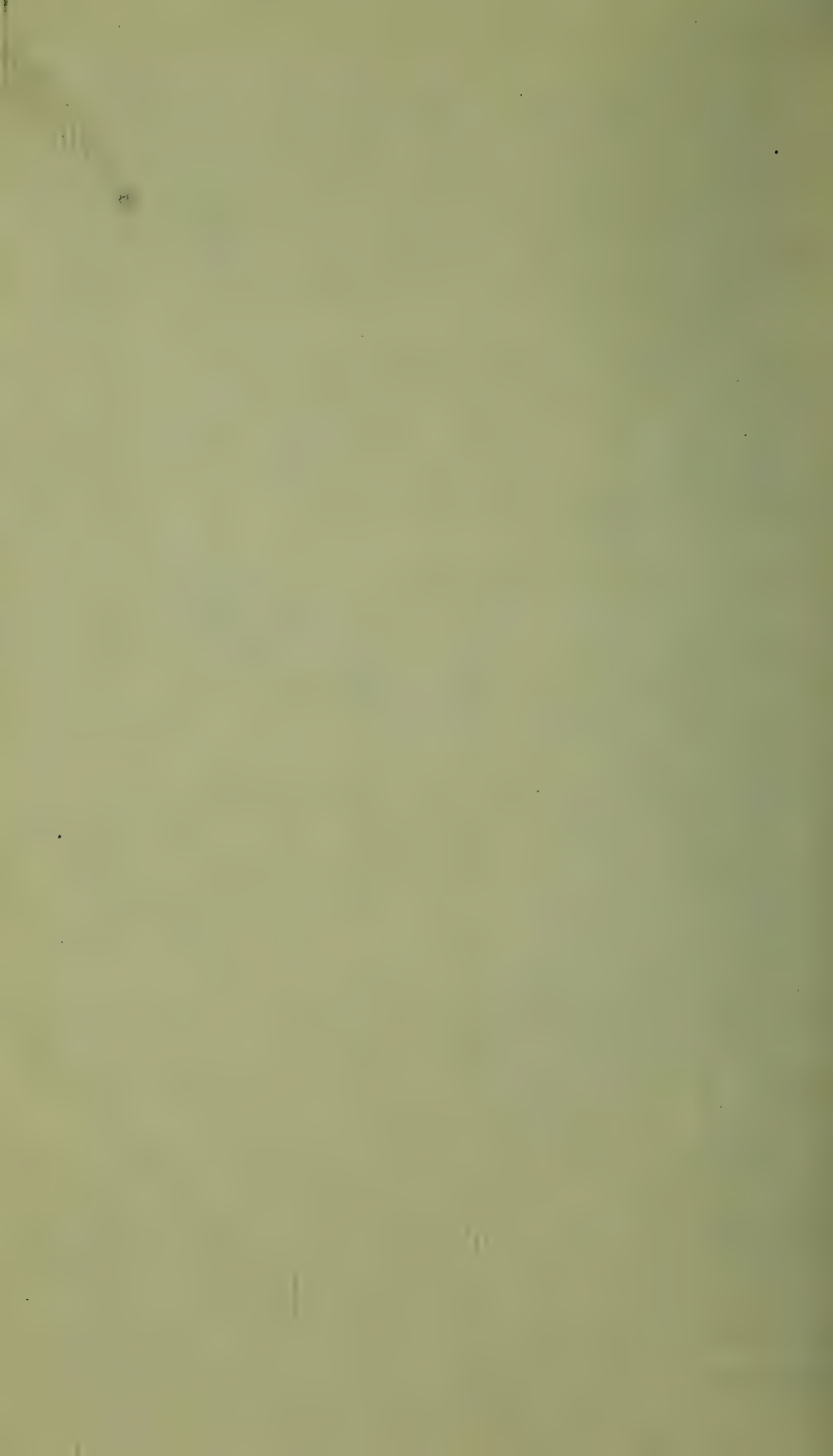
UNIVERSITY OF ILLINOIS

PRESIDENT'S OFFICE

MONTANA STATE SCHOOL OF MINES

BUTTE, MONTANA

1911-1912



MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

TENTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1910-1911

WITH ANNOUNCEMENTS FOR THE YEAR
1911-1912

CALENDAR FOR 1911-1912.

1911.

September 4, First Semester begins.

October 27, Close of First Term.

October 30, Second Term, First Semester begins.

November 30-December 1, Thanksgiving Recess.

December 22, End of First Semester.

1912.

January 3, Second Semester begins.

February 22, Washington's Birthday.

March 15, End of First Term, Second Semester.

March 18, Second Term, Second Semester begins.

June 7, Commencement Day.

September 2, First Semester begins.

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BOARDS OF CONTROL.

STATE BOARD OF EDUCATION.

MEMBERS EX-OFFICIO:

EDWIN L. NORRIS, Governor of the State,
President of the Board.

W. E. HARMON, Superintendent of Public Instruction,
Secretary of the Board.

ALBERT J. GALEN, Attorney General.

O. P. CHISHOLM

O. W. McCONNELL

H. G. PICKETT

G. T. PAUL

C. H. HALL

N. R. LEONARD

ROY E. AYRES

S. D. LARGENT

EXECUTIVE BOARD.

CHARLES H. BOWMAN,

President, Ex-Officio, and Treasurer.

J. C. ADAMS,

Secretary.

J. D. SLEMONS.

THE FACULTY.

CHARLES H. BOWMAN, M. S.,
President and Professor of Metallurgy.

GEORGE W. CRAVEN, B. S.,
Professor of Mathematics and Mechanics.

THEODORE SIMONS, E. M., C. E.,
Professor of Mining and Ore Dressing.

DARSIE C. BARD, A. B.,
Professor of Geology and Mineralogy.

LESTER J. HARTZEL, E. M.,
Professor of Chemistry.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Instructor in Surveying and Drawing.

EARLE B. YOUNG, A. M.,
Instructor in Mathematics and Mechanics.

CHARLOTTE RUSSELL,
Librarian and Registrar.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It was a significant date, and it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight other members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the campus overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given to this locality such publicity that no one now needs to be told of its leading position in the mining world.

Following a long period in which its mineral product, though larger than that of any other field, was kept far below its capacity by reason of conflict of title to mining ground, a settlement has been effected which will permanently remove all such restriction in its output. New life has been infused, new mines located, and such aggregations of capital have been enlisted as promise a vast increase in its production for a generation to come. With this increase in production, there has come a largely increased demand for copper, and a consequent advance in prices, that must for some years to come make the mining of the red metal in Butte one of the most profitable industries of the world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city must be enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry, and are thoroughly conversant with all the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the very extensive mining and metallurgical plants in the vicinity of the school.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter; the opportunity is here presented for daily observation of works, the development and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the school under the guidance of their instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for

eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the school. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building is fireproof and measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The library is located in a large, well-lighted room. The library together with the files of magazines is always open to access by the students. The room is maintained by a librarian and offers with its alcoves a cosy, convenient and quiet place for the students' study hours. The fourth floor is given up mainly to the exhibition of

a very extensive collection of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with requisite cabinets of rock specimens, thin sections, etc.; the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now in practice, a detailed account of which may be found under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gymnasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may be used also as a general auditorium on special occasions. Connected with the gymnasium and in the basement are two parlors, a dressing room and a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum pro-

vided for the biennium ending February 28, 1911, is \$33,000 per year.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The school is, therefore, wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind. Those who complete this course will receive the degree of Engineer of Mines.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five-minute periods per week; two laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above

requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which he comes.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

LIST OF ACCREDITED HIGH SCHOOLS IN THE STATE
OF MONTANA.

City High Schools.

Anaconda	Forsyth	Helena
Billings	Columbus	Havre
Butte	Fort Benton	Virginia City
Chinook	Great Falls	

County High Schools.

Beaverhead, Dillon	Granite, Philipsburg
Broadwater, Townsend	Jefferson, Boulder
Carbon, Red Lodge	Missoula, Missoula
Custer, Miles City	Park, Livingston
Dawson, Glendive	Powell, Deer Lodge
Fergus, Lewistown	Sweet Grass, Big Timber
Flathead, Kalispell	Teton, Choteau
Gallatin, Bozeman	

REQUIREMENTS FOR GRADUATION.

The school confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the

apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order. The balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR

General Chemistry and Qualitative Analysis.....	\$15.00
Surveying	10.00

SOPHOMORE YEAR

Mine surveying	\$10.00
Quantitative Analysis	15.00
Mineralogy	10.00
Deposit for Platinum Ware.....	30.00

JUNIOR YEAR

Metallurgy	\$10.00
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SENIOR YEAR

Metallurgy	\$15.00
Petrography	10.00

When the breakage exceeds the deposit the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as are approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY.

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	9	9
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	6	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Analytical Geometry	5	5
Plane Surveying, Theory.....	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	6	6
Mechanical Drawing	9	9

SOPHOMORE YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Mineralogy, Lectures	2	2
Mineralogy, Laboratory	0	6
Surveying, Field Work	15	0
Topographical Drawing	0	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus, Anal. Mechanics.....	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory	2	2
Mineralogy, Lectures	3	0
Geology, Lectures	0	3
Mineralogy, Laboratory	6	16

JUNIOR YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice.....	15	0
Chemistry	0	6
Graphics	0	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics and Hydraulics.....	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	6
Geology, Field Work	3	3
Metallurgy, Laboratory	3	3
Chemistry, Laboratory	3	3

SENIOR YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Geology	5	5
Mining	2	2
Ore Dressing, Lectures.....	0	3
Metallurgy	3	2
Power Transmission	3	3
Assaying	15	0
Geology, Field Work	0	3
Ore Dressing, Laboratory	0	3
Engineering Design	0	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mining	3	3
Ore Dressing, Lectures	2	2
Ore Dressing, Laboratory.....	3	3
Metallurgy, Lectures	3	3
Metallurgy, Laboratory	3	3
Mechanical Engineering	5	5
Engineering Design	6	6
Petrography	5	5

ENGLISH.

Two hours per week during the Freshman year are allotted to the study of English composition. The work is designed to continue the training outlined in the usual high school course, the chief aim being to create an individual and effective means of expression and communication for the ordinary demands of professional life. The ability to express oneself accurately and with some degree of elegance is an advantage which is not easily overestimated. At the same time the stimulating of literary sympathy and appreciation is kept in view, this we deem especially desirable in a professional course, as it supplies an element which is a source of pleasure in after life.

The work begins with a series of classroom lectures and discussions during which time the students are given simple exercises in writing, special attention is given to grammar, punctuation, choice of words, etc. Finally this work is extended to the study of the paragraph and the more complete theme.

During the latter part of the year the class is organized to develop the debate together with the regular theme writing. Proper form and fluency in speaking to an audience is a matter cultivated throughout the year. Among the other helpful features of the course may be mentioned a thorough and practical drill in parliamentary law, instruction on note taking, on making outlines, on writing examination papers and on the use of the library. The reading assignments for critical study are drawn mainly from the best technical magazines, from the best editorials, while occasionally a book of purely literary merit is assigned for review.

MATHEMATICS.

PROFESSOR CRAVEN, MR. ADAMI, MR. YOUNG.

Algebra.—A short preliminary course is first given, designed to drill the student in the fundamental operations and in the statement and solution of problems. The following topics constitute the chief items for the semester's work: Indeterminate coefficients; theory and use of logarithms; limits; introduction to derivatives; binomial and logarithmic equations; solution of numerical equations.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—In this course a systematic study is made of the following: The point and straight line in a plane; different systems of coordinates; conic sections; discussion of the general equation of the second degree with two variables; higher plane curves; the point and straight line in space; curved surfaces and surfaces of revolution. The text used is Wentworth's Analytic Geometry.

Freshman, second semester, three hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maxima and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia and work. The text used is Taylor's Differential and Integral Calculus.

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR BARD.

The geologic side of engineering is presented to the student through courses in Mineralogy, Geology and Petrography.

Mineralogy.—Text book is Dana's "Text-Book of Mineralogy." The purpose of this course is to familiarize the student with about three hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blowpipe Analysis, and by comparison with known mineral specimens, thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarizing the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other chemical tests of importance in mineralogy.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. Crystallography is a prerequisite.

The introductory lectures take up the characters of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.
Sophomores, first semester, second term, eight hours per week.
Sophomores, second semester, first term, nine hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Chamberlain and Salisbury's "College Geology."

The student is familiarized with a simple classification of rocks, in the use of which some time is devoted to laboratory practice. Field trips are taken to various points of geological interest, also some independent areal mapping is required of each student.

Juniors, first semester, five hours per week.
Juniors, second semester, first term, eight hours per week.

Economic Geology.—This course is devoted to a study of the more important economic deposits of the world, both metallic and non-metallic, with reference to their occurrence, geologic relations, origin and commercial value. The last term of the Junior year is devoted to the non-metallic minerals and the first term of the Senior year to the metallic minerals. Field trips are made to mines and quarries to supplement the lecture work. The text book used is Ries' "Economic Geology," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.
Seniors, first semester, first term, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps

of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—An optional course in microscopical petrography is provided for the senior year. This principles and objects of the use of the microscope are outlined in an earlier course. This optional course in microscopical work is designed for students who intend to specialize in geology. Johannsen's "Key to the Determination of Rock-forming Minerals" is used as a text. The student becomes familiar with the use of the petrographic microscope and is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Optional, Seniors, second semester, three hours per week.

CHEMISTRY.

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principles of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to the other, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from text-book references, and it is essential for those who take the course to take notes on the lectures which are designed to aid and direct the work performed in laboratory practice during the semester. The text book used is "Principles of Chemistry" by Kahlenberg.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

Freshmen, first semester, nine hours per week.

Freshmen, second semester, six hours per week.

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

*Freshmen, second semester, three hours lecture per week.
Freshmen, second semester, six hours laboratory per week.*

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such as, analysis of limestone, dolomites, rock analysis, ores of iron, magnese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, flue dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and laboratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these practical features are employed the instructor bears it ever in mind that through all the work the student must be required to use his own talents and learn to think and reason for himself.

*Sophomores, first semester, two hours lecture per week.
Sophomores, second semester, one hour lecture per week.
Sophomores, second semester, nine hours laboratory per week.*

METALLURGY.

PROFESSOR BOWMAN.

Introduction to Metallurgy.—The study of metallurgy begins with lectures and recitations on the fundamental principles of the art. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat

carried away by gasses, product of combustion, etc., are studied. The various fuel, solid, liquid, and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast, reverberatory, muffled, and electric, used in metallurgical operations are studied. In connection with this the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of the smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations studied is required of each student. The text book used is Peter's Principles of Copper Smelting.

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver—The second semester of the junior year is devoted to the metallurgy of gold and silver from lectures and text books. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The other metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiviation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student of the plant visited. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Zinc.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the

various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments, submitting a written report of the examinations made at the works.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

Senior, first semester, three hours per week.

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through references to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

MECHANICS.

PROFESSOR CRAVEN, MR. YOUNG.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts

as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text books used are: Elements of Mechanics, by Merriman; Elementary Lessons in Heat, by Tillman.

Sophomore, first semester, five hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Elementary Lessons in Electricity and Magnetism, by Jackson, is used as a text book.

Sophomore, second semester, six hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick,

cement, etc. Merriman's *Mechanics of Materials* is used as a text book.

Junior, first semester, three hours per week; second semester, two hours per week.

Applied Mechanics.—It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, supports for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application to mining machinery is found in the catalogues furnished us by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte.

Junior, first semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the west. The course is introduced with a brief review of hydraulics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over wires, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's *Treatise on Hydraulics* is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple, and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power houses are also made a part of this course. The text book used is *Steam Engines and Boilers*, by Kenneally.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr.

Senior, first semester, three hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmission, power transmission by continuous current, some properties of alternating circuits, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due to a locomotive, also stresses due to the wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. *Steel Mill Buildings*, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Senior, first semester, first term, nine hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; constructions of retaining walls, foundations dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is *Ketchum's Steel Mill Buildings*.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN.

PROFESSOR CRAVEN, MR. ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent

courses The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The following list is recommended; other minor necessities may be supplied as suggested later by the instructor: One $5\frac{1}{2}$ -inch compass, one $3\frac{1}{4}$ -inch bow divider, one $3\frac{1}{4}$ -inch bow pencil, one $3\frac{1}{4}$ -inch bow pen, one 5-inch ruling pen, one 8-inch $30^\circ \times 60^\circ$ amber triangle, one 8-inch $45^\circ \times 45^\circ$ amber triangle, one 12-inch architect's triangular scale, one T-square—36-inch blade, one drawing board 24x32 inches.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshman, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subjects laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, with the conventions used in mine and geological maps, and many other useful items used in mining. The text books are the same as used in the first course.

Freshman, second semester, six hours per week.

Machine Design.—This course is an application of the material presented in the second course in applied mechanics. The object is to give instruction in machine drawing so that repair parts for hoists, crushers, rolls, stamps, etc., may be correctly designed and represented. Attention is given to conventions, sections, correct lettering, and dimensioning. The problems are given entirely by dictation. Machine Design, by Low and Bevis, and Kent's Mechanical Engineer's

Hand Book are used as reference books. Several copies of these volumes are to be found on the tables of the drawing room.

Junior, first semester, second term, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING.

PROFESSOR SIMONS, MR. ADAMI.

Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requiring a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating quantities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Surveying.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Exercise in pacing, ranging, chaining and solution of geometrical problems with the chain. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Determination of elevations by aneroid barometer. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Sophomore, first semester, first term, fifteen hours per week.

Surveying.—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shaft by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the coordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, second term, six hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN.

PROFESSOR SIMONS.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Compression of air and air compressors. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The

lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines where mining operations are observed

Junior, first and second semesters, two hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, first semester, two hours per week.

Mining.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, six hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Description of the construction and operation of typical crushing machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, five hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general

offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

MINING LAW.

E. B. HOWELL.

A short course of lectures on mining law, particularly in regard to the rights of prospectors, the apex rights, water rights, the location of placer and lode claims, and the lateral rights of the locator as determiner under the laws of the United States and the State of Montana. The course consists of fifteen lectures and is required of juniors and seniors. The course is given every other year. It will be given in 1911-1912.

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the school. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. Fortunately it does not demand an extensive equipment. At the School of Mines it is furnished merely with a large recitation and lecture room on the second floor, abundantly supplied with blackboard space, and with slate, terrestrial and celestial globes, some simple models and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY AND METALLURGY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qualitative and quantitative analysis, one for metallurgy, and

two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of students in the laboratories. These balances are placed on stands which rest on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the students in the laboratories and all check analysis on the students' work are made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is

backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a buckboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold, and silver ores, together with mattes, both copper and lead, slag, flue-dusts, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for the hypo sulphite treatment. There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's

gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

A very complete set of the products of the metallurgical processes in use at the Boston & Montana smelter at Great Falls is installed in a series of the Museum cases; this includes an exhibit of electrolytic slime together with ingots showing the exact amount of copper, silver and gold recovered from a definite amount of this slime. There are also several views of the interior of the smelter and adjoining properties, as well as a flow sheet of the concentrator connected with the plant.

The Butte Reduction Works is represented by a large number of its metallurgical products, including concentrates, tailings, mattes, sulphur-coated ore, etc. The products of the Washoe smelter are also present, including samples of the copper cakes and anodes produced at Anaconda.

In addition to the mine models there are two metallurgical models in the Museum; one is a model of the Holthoff-Wethey calcining furnace, as in use at the Butte Reduction Works, showing the device by means of which the rails and wheels supporting the harrows are kept outside of the furnace proper; the other is a

model of the Pratt centrifugal ore sizer for sizing ore before it is run over Wilfley tables.

Several appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, of the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls, and of various mines and mills about the State. In addition, there is a large drawing to illustrate the method of sampling in use at the Washoe Sampling Works, and several drawings of the coal washery of the Cottonwood Coal Company.

The new ore testing and metallurgical laboratory occupies a separate building, 77 by 70 feet, half of which is devoted to metallurgical work. This contains complete cyanide and chlorination plants, a Wedge roasting furnace, a Bruckner calciner, a reverberatory furnace and other accessory appliances for metallurgical investigations capable of dealing with several tons of ore at a time.

Storage bins for ores, slags, etc., are provided and an adjoining room is being fitted up for electro metallurgical work, pyrometry, etc.

DEPARTMENT OF MINING AND ORE DRESSING.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following in-

struments have been provided: Six engineering transits; one from Buff and Buff, one from C. L. Berger & Sons, three from Gurley, and one from Keuffel and Esser. Four levels—one from Buff, one from Gurley, one from Keuffel and Esser and one from Berger. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plummets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four-foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Acces-

sories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs, Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four hundred pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Great

Falls concentrator, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies seven rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the museums, the petrographic laboratory, the dark room and the storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible to the students at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of the rarer, the larger and the more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geologic and areal maps. The dark room on the third floor contains apparatus and chemicals for photographic work. The storage room on the same floor contains materials which have not yet been prepared for study or exhibition.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercises. In addition to these real crystals, three series of crystal models are available, two of wood and one of celluloid. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Eighteen large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, geologic structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to Dana.

A collection of one hundred and sixty gold crystals is kept on exhibition in the library. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collections contain over one thousand specimens. The museum in all contains over six thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology.

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommodating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers, Westphal balances, Plattner scales, burettes, agate mortars and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here will also be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks.

The working paleontological collection consists of over one thousand catalogued fossils, systematically arranged in files of drawers in the office of the department.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels,

aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography.—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and two of them, one Leitz and one Nachet, are of a larger size than the others, and are equipped with accessories for research work. The school has just purchased from Fuess a very fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the museum contains two hundred and fifty-eight slides of minerals, six hundred and sixty-seven thin sections of rocks, and seventy-four slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are almost all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with the microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals. There are two electrically driven lathes in this room;

one is provided with two laps for rough and fine grinding respectively; the other with a wire and also with a wheel, both for cutting slides. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

The engine and dynamo room is located in the basement of the building; there is installed here a gas engine of fifteen horsepower, from which is belted a line shaft driving direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that

any number of them may be connected to any of the circuits for lecture or experimental purposes. The requisite voltmeters and ammeters for both alternating and direct currents, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subjected to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building and with its files of magazine is always open to access by the students. It is a large, well-lighted room and offers with its alcoves a cosy, convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others, is nearly 9,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; and Engineering Corps. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, and geological magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers.

A valuable collection of the standard works and treatises on the various branches of science taught in technical schools has been secured by donation.

MAGAZINES.

The following technical and general magazines and periodicals will be found in the library, where they may be freely consulted by the students:

- American Journal of Science.
- Anaconda Standard.
- Bulletin of the Geological Society of America.
- Bulletin of the International Bureau of American Republics.
- Cassier's Magazine.
- The Century.
- Chemical News.
- Collier's Weekly.
- Engineering Magazine.
- Engineering and Mining Journal.
- Engineering News.
- Electrical Age.
- Electrical World.
- Everybody's Magazine.
- Harper's Monthly.
- Harper's Weekly.
- Iron Age.
- Journal of the American Chemical Society.
- Journal of the Association of Engineering Societies.
- Journal of Geology.
- Journal of Geography.
- Journal of the Geological Society of Tokio.
- Life.
- Machinery (Engineering Edition).
- McClure's Magazine.
- Mineral Industry.
- Metallurgical and Chemical Engineering.
- Mines and Minerals.
- Mining and Scientific Press.
- Mining Magazine.

Mining Review.

Mining Science.

Mining World.

National Geographic Magazine.

Nature.

Neues Jahrbuch fur Geologie, Mineralogie, etc.

Outlook.

Outing Magazine.

Popular Science Monthly.

Review of Reviews.

Salt Lake Mining Review.

Saturday Evening Post.

Science Abstract.

Scribner's Magazine.

School of Mines Quarterly.

Technical World.

Transactions of the American Institute of Mining Engineers.

Tschermak's Mineralogische and Petrographische Mittheilungen.

World's Work.

The following newspapers are kindly furnished by their publishers free of charge:

The Ravalli Democrat (weekly), Hamilton.

Great Falls Leader (daily), Great Falls.

The Missoulian (daily), Missoula.

The Tribune-Review (weekly), Butte.

LIST OF STUDENTS.

SENIOR CLASS.

Clinch, R. S.....	Butte, Montana
Dailey, R. N. A.....	Great Falls, Montana
McElvenny, L. T.....	Butte, Montana
Murphy, J. K.....	Butte, Montana
O'Connor, C. H.....	Kanaskat, Washington
Peterson, P. E.....	Terraville, S. D.
Roach, J. C.....	Butte, Montana
Shields, E. F.....	Butte, Montana
Sultzor, H. D.....	Butte, Montana
Tout, Charles.....	Butte, Montana
Zentner, Arthur.....	Butte, Montana

JUNIOR CLASS.

Andrew, John T.....	Butte, Montana
Christian, O. B.....	Butte, Montana
Clinch, W. D.....	Butte, Montana
Cohen, Jesse.....	Anaconda, Montana
Cooke, Hamilton, Jr.....	St. Louis, Missouri
Cullity, Emmet.....	Berkeley, California
Fowler, George M.....	Lewistown, Montana
Gidel, Murl.....	Butte, Montana
Giovanetti, Ettore.....	Butte, Montana
Grupe, Charles.....	Vancouver, B. C.
Pilger, Theodore F.....	Butte, Montana
Williams, Paul.....	Butte, Montana

SOPHOMORE CLASS.

Crittenden, Zar T.....	Butte, Montana
Hanson, Wilbur.....	Butte, Montana
McAuliffe, Walter.....	Butte, Montana
McCoole, Edward.....	Butte, Montana
Manwaring, J. H.....	Ann Arbor, Mich.
Newton, Lucian.....	Butte, Montana
Osenbrug, Rudolph.....	Butte, Montana
Pierse, Edwin A.....	Great Falls, Montana
Reid, Milton.....	Anaconda, Montana

FRESHMAN CLASS.

Baker, Jacob.....	Butte, Montana
Brinton, Ben.....	Butte, Montana
Gagen, E. H.....	Spokane, Washington
Gibbons, James.....	Butte, Montana

Grupe, Gustave.....	Vancouver, B. C.
Hayes, Lee.....	Butte, Montana
Karri, Oskar.....	Finland
Kwan, David.....	San Francisco, California
Leon, Carl.....	Oskosh, Wisconsin
Lees, Charles E.....	Butte, Montana
Lyden, Joseph.....	Butte, Montana
MacPherson, Frank.....	Butte, Montana
McMahon, Brandon.....	Butte, Montana
Oaas, Torgus.....	Merrill, Wisconsin
Ternouth, Blaine.....	Butte, Montana

SPECIAL STUDENTS.

Cosgrove, Mack.....	Butte, Montana
Cullerton, M. J.....	Butte, Montana
Daoust, John F.....	Havre, Montana
Dorsey, S. L.....	Louisville Kentucky
Emery, J A.....	Butte, Montana
Ford, Harold.....	St. Joseph, Missouri
Jensen, W. H.....	Great Falls, Montana
Johnson, C. W.....	Butte, Montana
Naughton, Alice M.....	Butte, Montana
Rooney, James A.....	Butte, Montana
Silverman, H. L.....	Butte, Montana
Swinborne, J. A.....	Butte, Montana

REGISTER OF ALUMNI.

CLASS 1903.

Bender, Louis V.....Anaconda, Montana
Supt. Blast Furnaces, A. C. M. Company.

CLASS 1904.

Balmforth, Alfred J....San Antonio de la Huerta, Sonora, Mex.
 Duling, Fred J.....Los Angeles, Cal.
Supt. Pacific-American Development Co.

Ireland, Arthur J.....Helena, Montana
Mining Engineer.

Kuphal, Henry E.....Missoula, Montana
Mining Engineer, Kuphal & Bonner, Mining and Civil Engineers.

MacRae, Lachlan D.....Nacozari de Garcia, Sonora, Mex.
Phelps-Dodge Company.

McGee, John Los Angeles, California
General Manager Greenwater Copper Mines & Smelter Co.

Pauly, P. L.....Basin, Montana
Supt. Montana Mineral Land Development Co.

Reese, Clara Clark.....Denver, Colorado

Stevenson, Isabel Little.....Berlin, Pennsylvania

Tallant, H. S.....Victoria, B. C.
Engineer Tyce Copper, Ltd.

CLASS 1905.

Archibald, George B.....Helena, Montana
Mineral Inspector, G. F. O.

Brinton, Owen F.....Golconda, Illinois
Ass't Supt. Fairview Fluor Spar & Lead Company.

Corey, Clarence R.....Seattle, Washington
Instructor of Metallurgy, School of Mines, University of Washington.

Duthie, John M.....Libby, Montana
County Surveyor.

Elford, Basil.....Tonopah, Nevada
Assayer, Tonopah Extension Mining Co.

Mackel, Louis.....Long Beach, Cal.

Pratt, Paul D.....Libby, Montana
Mining and Civil Engineer.

Stevenson, L. C.....Berlin, Pennsylvania
Engineer and Chemist, Brothers Valley Coal Co.

Van Gundy, Jay.....Bluff, Utah
Mgr. Pioneer Development Co., San Juan Oil Fields.

CLASS 1906.

Dugan, John F.....Butte, Montana
Engineer, A. C. M. Company.

Feeney, Charles W.....Butte, Montana
Ass't Foreman, Diamond Mine, A. C. M. Company.

Geiser, Herbert S.....	Cerro de Pasco, Peru
<i>Chemist, Cerro de Pasco Mining Company.</i>	
Johns, John W.....	Wickes, Montana
<i>General Superintendent Blue Bird Mine.</i>	
Kane, L. M.....	Butte, Montana
<i>Foreman, Berkeley Mine, A. C. M. Company.</i>	
Warfield, Hershel.....	Butte, Montana
<i>Mining Engineer, B. & M. Company.</i>	
Wilson, T. Bert.....	Goldendale, Wash.
<i>Consulting Engineer, Irrigation and Mining.</i>	
Young, Arthur B.....	Hamburg, Arizona
<i>Mining Engineer, Hartford-Arizona Copper Mining Co.</i>	
Young, Siegfried A.....	Hamburg, Arizona
<i>Superintendent, Hartford-Arizona Mining Co.</i>	

CLASS 1907.

Adami, Arthur E.....	Butte, Montana
<i>Instructor Surveying and Drawing, Montana State School of Mines.</i>	
Bovett, Clifford A.....	Mason, Nevada
<i>Engineer, Mason Valley Gold Mining Co.</i>	
McCracken, Ralston H.....	Cerro de Pasco, Peru
<i>Shift Boss, Esperanz Mine.</i>	
Reardon, Daniel.....	Missoula, Montana
<i>Assistant City Engineer.</i>	
Schafer, William A.....	Metcalf, Arizona
<i>Engineer, Arizona Copper Mining Company.</i>	

CLASS 1908.

Bowden, Malcolm.....	Elkhorn, Montana
<i>Engineer, Elkhorn Silver Mining Company.</i>	
Ellis, Willis H.....	Virginia City, Mont.
<i>Assayer and Surveyor, Apex Mining Company.</i>	
Foote, Frank A.....	Missoula, Montana
<i>Mineral Examiner, U. S. Department of Agriculture.</i>	
Ketcham, S. H.....	Hamilton, Montana
<i>Engineer, Bitter Root Valley Irrigation Company.</i>	
Lomas, E. P.....	Butte, Montana
<i>Sampler, Tramway Mine, A. C. M. Company.</i>	
Lowry, Thomas M.....	Butte, Montana
McLaughlin, William D.....	Butte, Montana
<i>Surveyor, Tramway Mine, A. C. M. Company.</i>	
Meiklejohn, Archie B.....	La Luz, Guanaajuato, Mexico
O'Brien, Albert.....	Butte, Montana
<i>Mining Engineer for Barker & Wilson.</i>	
Patten, Earle.....	Philipsburg, Montana
Proctor, I. O.....	Placerville, Idaho
<i>Manager Placer Property.</i>	
Proctor, M. D.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Schiffner, Otto E.....	Campo Seco, Cal
<i>Surveyor, Penn. Mining Company.</i>	

Villars, Jesse R.....	Great Falls, Mont.
<i>President, Villars-Barnum Engineering Company.</i>	
Walton, Lee M.....	Butte, Montana
<i>Engineer, A. C. M. Company.</i>	
Wren, Andrew A.....	

CLASS 1909.

Brulo, William.....	Helena, Montana
Evans, James R.....	Butte, Montana
<i>Engineering Dept., Butte & Superior Copper Co., Ltd.</i>	
Gilham, Ralph E.....	Radersburg, Montana
<i>Engineer, Keating Gold Mining Company.</i>	
Haines, Peter A.....	Elk City, Idaho
<i>Superintendent, Del Rio Mining Company.</i>	
Johnstone, J. Clark.....	Spokane, Wash.
<i>Mining Engineer.</i>	
Kane, Edward G.....	Butte, Montana
<i>Mining Engineer, A. C. M. Company.</i>	
Kirby, Kenneth P.....	Anaconda, Mont.
<i>Chemist, Washoe Smelter, A. C. M. Co.</i>	
Loughran, Michael.....	Butte, Montana
<i>Engineering Dept., A. C. M. Company.</i>	
Malloy, Edward F.....	Virginia City, Montana
<i>Assayer, Easton Mine.</i>	
Peters, Ira B.....	Butte, Montana
Stockett, Norman A.....	Chicago, Illinois
<i>Draftsman, Link Belt Company.</i>	
Weigenstein, Henry J.....	Butte, Montana
<i>Shift Boss, M. H. Mine.</i>	
Young, William A.....	Maiden, Montana
<i>Mine Foreman, Maginnis Mine.</i>	

CLASS 1910.

Grunert, August.....	Butte, Montana
<i>Chemical Department, A. C. M. Company.</i>	
Jensen, Walter H.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Stuewe, William, Jr.....	Helena, Montana
<i>Manager Gold Queen Mining Company.</i>	

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LIBRARY
OF THE
MONTANA STATE SCHOOL OF MINES

MONTANA STATE SCHOOL OF MINES

BUTTE, MONTANA

1912-13

LIBRARY
OF THE
UNIVERSITY OF CALIFORNIA

MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

ELEVENTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1911-1912

WITH ANNOUNCEMENTS FOR THE YEAR
1912-1913

CALENDAR FOR 1912-1913.

1912.

September 3, First Semester begins.

October 25, Close of First Term.

October 28, Second Term, First Semester begins.

November 28 and 29, Thanksgiving Recess.

December 20, End of First Semester.

1913.

January 6, Second Semester begins.

February 22, Washington's Birthday.

March 21, End of First Term, Second Semester.

March 24, Second Term, Second Semester begins.

June 6, Commencement Day.

September 2, First Semester begins.

1912

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BOARDS OF CONTROL.

STATE BOARD OF EDUCATION.

MEMBERS EX-OFFICIO:

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President of the Board.

W. E. HARMON, Superintendent of Public Instruction.
Secretary of the Board.

ALBERT J. GALEN, Attorney.

S. D. LARGENT

W. S. HARTMAN

H. G. PICKETT

G. T. PAUL

C. H. HALL

N. R. LEONARD

WARD H. NYE

O. W. McCONNELL

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J. D. SLEMONS

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President and Professor of Metallurgy.

GEORGE W. CRAVEN, B. S.,
Professor of Mathematics and Mechanics.

THEODORE SIMONS, E. M., C. E.,
Professor of Mining Engineering.

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LESTER J. HARTZELL, E. M.,
Professor of Chemistry.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAM, E. M.,
Assistant Professor of Mining Engineering.

EARLE B. YOUNG, A. M.,
Instructor in Mathematics and Mechanics.

CHARLOTTE RUSSELL,
Librarian and Registrar.

M. F. HALEY,
Assistant Millman.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It was a significant date, and it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight other members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public-spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the campus overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given this locality such publicity that no one now needs to be told of its leading position in the mining world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city must be enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the extensive mining and metallurgical plants in the vicinity of the School.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter, the opportunity is here presented for daily observation of works, the develop-

ment and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the School under the guidance of their instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the School. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The library is located in a large, well-lighted room. The library together with the files of magazines is always open to access by the students. The room is maintained by a librarian and offers with its alcoves a convenient and quiet place for the students' study hours. The fourth floor is given up mainly to museums containing extensive collections of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with requisite cabinets of rock specimens, thin sections, etc.; the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now

in practice, a detailed account of which may be found under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gymnasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may be used also as a general auditorium on special occasions. Connected with the gymnasium and in the basement are two parlors, a dressing room and a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1913, is \$33,000 per year.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The school is, therefore, wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind. Those who complete this course will receive the degree of Engineer of Mines.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a

passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which he comes.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

LIST OF ACCREDITED HIGH SCHOOLS IN THE STATE
OF MONTANA.

City High Schools.

Anaconda	Forsyth	Helena
Billings	Columbus	Havre
Butte	Fort Benton	Virginia City
Chinook	Great Falls	

County High Schools.

Beaverhead, Dillon	Granite, Philipsburg
Broadwater, Townsend	Jefferson, Boulder
Carbon, Red Lodge	Missoula, Missoula
Custer, Miles City	Park, Livingston
Dawson, Glendive	Powell, Deer Lodge
Fergus, Lewistown	Sweet Grass, Big Timber
Flathead, Kalispell	Teton, Choteau
Gallatin, Bozeman	

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order. The balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR.

General Chemistry and Qualitative Analysis.....\$15.00

SOPHOMORE YEAR.

Surveying	\$10.00
Quantitative Analysis	15.00
Mineralogy	10.00
Deposit for Platinum Ware.....	30.00

JUNIOR YEAR.

Mine Surveying	\$10.00
Metallurgy	10.00

SENIOR YEAR.

Metallurgy and Assaying.....	\$15.00
Petrography	10.00

When the breakage exceeds the deposit the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as are approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY.

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	9	9
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	6	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Analytical Geometry	5	5
Plane Surveying, Theory.....	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	6	6
Mechanical Drawing	9	9

SOPHOMORE YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Mineralogy Lectures	2	2
Mineralogy, Laboratory	0	6
Surveying, Field Work	15	0
Topographical Drawing	0	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus, Anal. Mechanics....	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory	2	2
Mineralogy, Lectures	3	0
Geology, Lectures	0	3
Mineralogy, Laboratory	6	6

JUNIOR YEAR

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice.....	15	0
Chemistry	0	6
Graphics	0	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics and Hydraulics.....	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	6
Geology, Field Work.....	3	3
Metallurgy, Laboratory	3	3
Chemistry Laboratory	3	3

SENIOR YEAR

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Geology	5	5
Mining	2	2
Ore Dressing, Lectures.....	0	3
Metallurgy	3	2
Power Transmission	3	3
Assaying	15	0
Geology, Field Work.....	0	3
Ore Dressing, Laboratory.....	0	3
Engineering Design	0	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mining	3	3
Ore Dressing, Lectures	2	2
Ore Dressing, Laboratory	3	3
Metallurgy, Lectures.....	3	3
Metallurgy, Laboratory	3	3
Mechanical Engineering	5	5
Engineering Design	6	6
Petrography	5	5
Mining Law	5	0

ENGLISH.

Two hours per week during the Freshman year are allotted to the study of English composition. The work is designed to continue the training outlined in the usual high school course, the chief aim being to create an individual and effective means of expression and communication for the ordinary demands of professional life. The ability to express oneself accurately and with some degree of elegance is an advantage which is not easily overestimated. At the same time the stimulating of literary sympathy and appreciation is kept in view, this we deem especially desirable in a professional course, as it supplies an element which is a source of pleasure in after life.

The work begins with a series of classroom lectures and discussions during which time the students are given simple exercises in writing, special attention is given to grammar, punctuation, choice of words, etc. Finally this work is extended to the study of the paragraph and the more complete theme.

During the latter part of the year the class is organized to develop the debate together with the regular theme writing. Proper form and fluency in speaking to an audience is a matter cultivated throughout the year. Among the other helpful features of the course may be mentioned a thorough and practical drill in parliamentary law, instruction on note taking, on making outlines, on writing examination papers and on the use of the library. The reading assignments for critical study are drawn mainly from the best technical magazines, from the best editorials, while occasionally a book of purely literary merit is assigned for review.

MATHEMATICS.

PROFESSOR CRAVEN, MR. ADAMI, MR. YOUNG.

Algebra.—A preliminary course is first given designed to drill the student in the fundamental algebraic operations and in the statement and solution of simple mechanical problems. This review is followed for the remainder of the semester by a careful study of those operations of advanced algebra which will be of use to the student in future engineering courses. Special attention is given to the theory and use of exponents and ligarithms, simultaneous quadratic equations, the more common series with their practical applications, indeterminate coefficients and quantics solved by synthetic division and by graphical methods. Text, Wentworth's College Algebra.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—This course from its very nature becomes a thorough review of algebra, geometry and trigonometry. The material gathered from these three sources is combined in a most striking way which leads to a more practical working knowledge of these branches of mathematics. The student is required to study and plot accurately several hundred problems covering such topics as, the point and straight line in a plane, different systems of co-ordinates, conic sections, higher plane curves, the point and straight line in space, curved surfaces and surfaces of revolution. Toward the end of the course the student is required to study various mechanical movements, to invent movements and to determine the laws and equations involved.

Text Wentworth's Analytical Geometry.

Freshman, second semester, five hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maxima and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia and work. The text used is Taylor's Differential and Integral Calculus.

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR BARD.

The geologic side of engineering is presented to the student through courses in Mineralogy, Geology and petrography.

Mineralogy.—Text book is Dana's "Text-Book of Mineralogy." The purpose of this course is to familiarize the student with about three hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blow-pipe Analysis, and by comparison with known mineral specimens, thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarizing the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other chemical tests of importance in mineralogy.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. Crystallography is a prerequisite. The introductory lectures take up the characters of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.

Sophomores, first semester, second term, eight hours per week.

Sophomores, second semester, first term, nine hours per week.

Sophomores, second semester, second term, six hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Chamberlain and Salisbury's "College Geology."

The student is familiarized with a simple classification of rocks, in the use of which some time is devoted to laboratory practice. Field trips are taken to various points of geological interest, also some independent areal mapping is required of each student.

Juniors, first semester, five hours per week.

Juniors, second semester, first term, eight hours per week.

Sophomores, second semester, second term, three hours per week.

Economic Geology.—This course is devoted to a study of the more important economic deposits of the world, both metallic and non-metallic, with reference to their occurrence, geologic relations, origin and commercial value. The last term of the Junior year is devoted to the non-metallic minerals, and the first term of the Senior year to the metallic minerals. Field trips are made to mines and quarries to supplement the lecture work. The text book used is Ries' "Economic Geology," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.

Seniors, first semester, first term, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—An optional course in microscopical petrography is provided for the senior year. The principles and objects of the use of the microscope are outlined in an earlier course. This optional course in microscopical work is designed for students who intend to specialize in geology. Johannsen's "Key to the Determination of Rock-forming Minerals" is used as a text. The student becomes familiar with the use of the petrographic microscope and is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Optional, Seniors, second semester, five hours per week.

CHEMISTRY.

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principles of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to another, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from

text-book references, and it is essential for those who take the course to take notes on the lectures which are designed to aid and direct the work performed in laboratory practice during the semester. The text book used is "Principles of Chemistry" by Kahlenberg.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

Freshmen, first semester, nine hours per week.

Freshmen, second semester, six hours per week.

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

Freshmen, second semester, three hours lecture per week.

Freshmen, second semester, six hours laboratory per week.

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such as, analysis of limestone, dolomites, rock analysis, ores of iron, magnese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, flue dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and labratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these prac-

tical features are employed the instructor bears it ever in mind that through all the work the student must be required to use his own talents and learn to think and reason for himself.

Sophomores, first semester, two hours lecture per week.

Sophomores, second semester, one hour lecture per week.

Juniors, second term, first semester, six hours per week.

Fire Assaying.—The course in fire assaying is essentially a laboratory drill course. It comes during the Junior and Senior years when the students are already familiar with the reagents and most of the chemical reactions used in the work. However, the laboratory work is preceded by a short course in lectures in which the general principles of the art are developed and all equipment carefully explained. Attention is given to the proper care of the furnace and method of controlling the temperature. The special balances used in this work are demonstrated showing methods of operating, care and adjustments. Finally the class is given a series of notes which embody a description of the charges in actual use in the mining and smelting plants of the West.

In the laboratory work each student is given a desk with a full equipment of reagents and apparatus. Ample furnace room, balances and ore-grinding apparatus are provided so no delays are encountered through lack of equipment. Then each student works through his individual list of ores to be assayed. There are silicious oxidized ores, basic oxidized ores, ores of lead, copper and zinc; all containing various impurities. These are assayed for gold and silver and when lead is present it is also determined. The smelter products likewise receive attention; lead and copper mattes, speiss, antimonial lead, lead and copper bullion, lead and copper slags are all treated according to the custom about the laboratory of the smelter.

Both crucible and scorification methods are used where considered practicable while the combined wet and dry methods are used upon material such as copper bullion, mattes high in copper, blister copper, etc.

The laboratory work covers about ten weeks of five afternoons each week. Throughout the course speed and accuracy are considered essential points. Before a student is considered proficient he must be able to accomplish what may be considered a reasonable day's work in a commercial laboratory. Accuracy is required, but it is not sufficient, the time is considered equally important.

In this course no charge is made for materials or equipment except where there is an unnecessary breakage or consumption of material.

Senior, first semester, first term, five afternoons per week.

METALLURGY.

PROFESSOR BOWMAN, MR. HALEY.

Introduction to Metallurgy.—The study of metallurgy begins with lectures and recitations on the fundamental principles of the science. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, products of combustion, etc., are studied. The various fuel, solid, liquid, and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast reverberatory, muffled, and electric, used in metallurgical operations are described. In connection with this the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations observed is required of each student. The text book used is Peter's Practice of Copper Smelting.

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver.—The second semester of the junior year is devoted to the metallurgy of gold and silver. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The other metallurgical processes for silver, such as the Washoe

process and the hyposulphite lixiviation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Silver.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments submitting a written report of the examinations made at the works.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

Senior, first semester, three hours per week.

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through references to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

Metallurgy Laboratory.—During one semester of the Junior year the class spends one afternoon per week conducting laboratory experiments which illustrate the principles and chemical reactions studied in the class room. There are experiments in roasting which are conducted so as to yield quantitative results in regard to formation of oxides, sulphides, etc. The more delicate problems of roasting which involve chloridizing various ores are also carried out. In these experiments all the important reactions are produced and observed. During the course each student makes up a series of slags and determines their melting points, viscosity, etc. During the work requiring the use of the furnace, a familiarity with the various types of pyrometers is obtained. The latter part of the semester is taken up with an analysis of fuels, this work includes the determination of the calorific power of the fuels by means of the bomb and the Parr calorimeters. The analysis of fuel gases and flue gases are carried out by the Hempel apparatus and by means of some of the more simple units where a complete analysis is not required.

Junior, second semester, one afternoon per week.

Metallurgy Laboratory.—The work of the last semester of the Senior year includes the testing of ores on a commercial scale. For this work ore of various kinds and grades are collected in the ore bins of the School's mill. From this point it is sampled and analyzed by the students and a proposed scheme of treatment laid out. A small sample is then tested according to the scheme submitted. For this work each student is given a regular chemical desk and has access to the special equipment required in concentrating, such as small classifiers, jigs and tables, and such equipment as is required for the lixiviation processes including small agitation vats, filters, etc.

Among the tests may be mentioned any of the processes of concentration requiring trommels, classifiers, jigs, tables, vanners, wet and dry screens, dewatering devices, etc. For this work there are crushers, rolls, mills, etc., so arranged as to reduce the handling of the ore by hand to a minimum. A battery of three stamps offers practice in stamp milling during which tests the class is given practice in dressing the plates and recovering the bullion. Other tests involve amalgamating pans, cyanide vats, of five tons capacity, a slime and agitation equipment, a lead-lined agitation barrel, etc. There are also large roasting furnaces with which any of the roasting operations may be carried out that are required in the standard processes of ore treatment.

During this work much attention is given to the handling and adjusting of machinery. Under proper instruction the students operate the mill from the power plant to the end. This experience is a valuable asset to any young engineer undertaking work, especially with the smaller plants of the West.

Senior year, second semester, one afternoon per week.

MECHANICS.

PROFESSOR CRAVEN, MR. YOUNG.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text book used is Elements of Mechanics, by Merriman.

Sophomore, first semester, six hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and

heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Elementary Lessons in Electricity and Magnetism, by Jackson, is used as a text book.

Sophomore, second semester, four hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc. Merriman's Mechanics of Materials is used as a text book.

Junior, first semester, three hours per week; second semester, two hours per week.

Applied Mechanics.—It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, supports for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application to mining machinery is found in the catalogues furnished us by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte.

Junior, first semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the West. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over wires, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's Treatise on Hydraulics is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple, and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power houses are also made a part of this course. The text book used is *Steam Engines and Boilers*, by Kenneally.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M Barr.

Senior, first semester, three hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmission, power transmission by continuous current, some properties of alternating circuits, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due to a locomotive, also stresses due to the wind, etc. The work

is carried out in the drawing room, supplemented by lectures and recitations. Steel Mill Buildings, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Senior, first semester, first term, nine hours per week.

Engineering 'Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; constructions of retaining walls, foundations, dams etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum' Steel Mill Buildings.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN.

PROFESSOR CRAVEN, ASSISTANT PROFESSOR ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The following list is recommended; other minor necessities may be supplied as suggested later by the instructor: One 5½-inch compass, one 3¼-inch bow divider, one 3¼-inch bow pencil, one 3¼-inch bow pen, one 5-inch 45°x45° amber triangle, one 12-inch architect's triangular scale, one T-square—36-inch blade.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshman, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subjects laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers and head frames, with the conventions used in mine and geological maps, and many other useful items used in mining. The text books are the same as used in the first course.

Freshman, second semester, six hours per week.

Descriptive Geometry.—Two hours per week throughout the freshman year are occupied with recitations in descriptive geometry. Throughout the course the students study assigned lessons from a text book, this study affords a knowledge of the principles involved together with the notation work, etc. The class period is taken up for the most part with the working of new problems, especially those involving the point, line and plane; it is a drill hour in rapidity and accuracy in the application of the essential features of the subject. The procedure insures a thorough mastery of all the elements, an acquisition which is of great value in much of the work of the mining engineer. It assists him in his mechanical drawing and designing, it is indispensable in many problems in mine surveying and aids greatly in part of the work in geology especially in the practical work in mines where faults and veins are traced and platted.

The latter part of the work where the more complicated intersections of solids and developments of surfaces are required, the class works in the drawing room over the drawing boards. Here the problems are likewise varied so that the possibility of merely copying or committing to memory are eliminated. The course follows in close touch with the regular mechanical drawing where the more elaborate drawings are completed, dimensioned and inked. The text used is Faunce's Descriptive Geometry.

Freshman year, two hours per week.

Machine Design.—This course is an application of the material presented in the second course in applied mechanics. The object is to give instruction in machine drawing so that repair parts for hoists, crushers, rolls, stamps, etc., may be correctly designed and represented. Attention is given to conventions, sections, correct lettering, and dimensioning. The problems are given entirely by dictation. Machine Design, by Low and Bevis, and Kent's Mechanical Engineer's

Hand Book are used as reference books. Several copies of these volumes are to be found on the tables of the drawing room.

Junior, first semester, second term, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Plane Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requiring a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Mine Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating qualities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Plane Surveying, Field Work.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Exercise in pacing, ranging, chaining and solution of geometrical problems with the chain. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Determination of elevations by aneroid barometer. Staking out buildings and excavations for foundations and

calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Sophomore, first semester, first term, fifteen hours per week.

Surveying—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shift by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the co-ordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods.

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, second term, six hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work,

rotary and percussion drills. Compression of air and air compressors. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines where mining operations are observed.

Junior, first and second semesters, two hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Junior, second semester, two hours per week.

Air Compression.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, first semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, six hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Description of the construction and operation of typical crushing machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, five hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

MINING LAW.

EDWARD B. HOWELL OF THE BUTTE BAR.

A course of instruction on the law relating to mining claims including the method of acquiring title from the United States to lode, placer, tunnel and mill-site claims in the various states and Alaska, with a comparative study of federal and state laws on the subject, the law relating to extra-lateral rights, leases, options to purchase, conveyances of mining claims, and water rights, the relative rights of citizens and aliens in the tenure of mining claims. The object of the course is to give the student a good working knowledge of mining law, and to this end students are required to draft location notices and similar instruments that might become necessary in their work in the field. Through the recitations the class is given a thorough drill in rights of the locator also in ways in which these rights may be transmitted or may be forfeited, all principles being abundantly illustrated by actual and hypothetical cases. Questions of more complexity

are illustrated by elaborate models and charts, many of these models were constructed to represent the claims of mining companies in the courts.

The course in Mining Law consists of lectures and recitations covering a period of two months and is required of the senior class. The class uses as a text book for this course Mr. Howell's manual on "Lode and Placer Claims."

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the School. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. Fortunately it does not demand an extensive equipment. At the School of Mines it is furnished merely with a large recitation and lecture room on the first floor, abundantly supplied with blackboard space, and with slate, terrestrial and celestial globes, some simple models and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is

great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qualitative and quantitative analysis, one for metallurgy, and two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of students in the laboratories. These balances are placed on stands which rest on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the

students in the laboratories and all check analyses on the students' work are made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces and one gasoline furnace, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a buckboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold, and silver ores, together with mattes, both copper and lead, slag, flue-dusts, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for the hypo sulphite treatment. There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

DEPARTMENT OF MINING AND ORE DRESSING.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing-boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used

as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following instruments have been provided: Ten engineering transits; one from Buff and Buff, two from C. L. Berger & Sons, four from Gurley, one from Keuffel and Esser, one from Young & Son, and one from Eugene Dietzgen. Five levels—one from Buff, one from Gurley, two from Keuffel and Esser, one from Berger, and one from Young & Son. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plummets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diam-

eter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four-foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs, Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four hundred pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a

large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Great Falls concentrator, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other States.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies seven rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps;

and on the third floor are the museums, the petrographic laboratory, dark room and storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of the rarer, the larger and the more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geologic and areal maps. The dark room on the third floor contains apparatus and chemicals for photographic work. The storage room on the same floor contains materials which have not yet been prepared for study or exhibition.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercises. In addition to these real crystals, three series of crystal models are available, two of wood and one

of celluloid. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Eighteen large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, geologic structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to the Dana classification. A collection of one hundred and sixty gold crystals is kept on exhibition in the library. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collections contain over one thousand specimens. The museum in all contains over six thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology.

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommodating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers,

Westphal balances, Plattner scales, burettes, agate mortars and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here will also be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analyses of minerals and rocks.

The working paleontological collection consists of over one thousand catalogued fossils, systematically arranged in files of drawers in the office of the department.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels, aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography.—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and two of them, one Leitz and one Nachet, are of a larger size than the others, and are equipped with accessories for research work. The School has purchased from Fuess a very fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the museum contains three hundred slides of minerals, six hundred thirty thin sections of rocks, and seventy-four slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes

and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are almost all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with the microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a wire and also with a wheel, both for cutting slides. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evapora-

tion, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

An engine and dynamo laboratory is located in the basement of the building; there is installed here a gas engine of ten horsepower for experimental purposes. A ten horsepower three phase induction motor drives direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. It is charged from the direct current dynamo or mercury arc rectifier. The requisite voltmeters and ammeters for both alternating and direct currents, reho-stats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

The power plant for the mill contains two 80 horsepower boilers, a 75 horsepower high speed engine belted to a 50 K. W., three phase generator with switchboard and necessary instruments, and an air compressor with steam cylinders 8-inch by 10-inch and air cylinders 7½-inch and 13-inch by 10-inch.

In connection with this laboratory there is a small shop equipped with the following metal working machines:

One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subjected to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building and with its files of magazines is always open to access by the students. It is a large, well-lighted room and offers with its alcoves a convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others, is nearly 9,000. As a United States

Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; and Engineering Corps. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, and geological magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers.

A valuable collection of the standard works and treatises on the various branches of science taught in technical schools has been secured by donation.

MAGAZINES.

The following technical and general magazines and periodicals are on file in the library, where they may be freely consulted by the students:

American Journal of Science.

Anaconda Standard.

Bulletin of the Geological Society of America.

Bulletin of the International Bureau of American Republics.

Cassier's Magazine.

The Century.

Chemical News.

Collier's Weekly.

Economic Geology.

Engineering Magazine.

Engineering & Mining Journal.

Engineering News.

Electrical World.

Everybody's Magazine.

Harper's Monthly.

Harper's Weekly.

Iron Age.

Journal of American Chemical Society.

Journal of the Association of Engineering Societies.

Journal of Geology.

Journal of Geography.

Journal of the Geological Society of Tokio.

Life.

Literary Digest.

Machinery (Engineering Edition).

McClure's Magazine.

Mineral Industry.

Metallurgical & Chemical Engineering.

Mines & Minerals.

Mining & Scientific Press.

Mining Magazine.

Mining Review (Los Angeles).

Mining Review (Salt Lake).

Mining Science.

Mining World.

National Geographic Magazine.

Nature.

Neues Jarbuch fur Geologie, Mineralogie, etc.

Outlook.

Outing Magazine.

Popular Science Monthly.

Quarterly Journal of the Geological Society of London.

Review of Reviews.

Saturday Evening Post.

Science Abstract, both sections.

Scribner's Magazine.

School of Mines Quarterly.

Technical World.

Transactions of the American Institute of Mining Engineers.

World's Work.

Zeitschrift fur Praktische Geologie.

The following newspapers are kindly furnished by their publishers free of charge:

The Ravalli Democrat (weekly), Hamilton.

Great Falls Leader (daily), Great Falls.

The Missoulain (daily), Missoula.

The Tribune-Review (weekly), Butte.

LIST OF STUDENTS.

SENIOR CLASS.

Andrew John T.....	Butte, Montana
Bassett, Arthur F.....	Butte, Montana
Christian, O. B.....	Butte, Montana
Clinch, W. D.....	Butte, Montana
Cohen, Jesse.....	Anaconda, Montana
Cooke, Hamilton, Jr.....	St. Louis, Missouri
Cullity, Emmet.....	Berkeley, California
Fowler, George M.....	Lewistown, Montana
Gidel, Murl.....	Butte, Montana
Giovanetti, Ettore.....	Butte, Montana
Grupe, Charles W.....	Vancouver, B. C.
Pilger Theodore F.....	Loup City, Nebraska
Williams, Paul.....	Butte, Montana

JUNIOR CLASS.

Crittenden, Zar T.....	Mt. Pleasant, Michigan
Dobson, Chris G.....	Seattle, Washington
Hanson Wilbur.....	Butte, Montana
McCoole Edward J.....	Butte, Montana
Manwaring, Joe.....	Ann Arbor, Michigan
Pierse, Edwin A.....	Great Falls, Montana
Reid, Milton A.....	Anaconda, Montana

SOPHOMORE CLASS.

Baker, Jacob H.....	Butte, Montana
Brinton Ben H.....	Butte, Montana
Kwan, David S.....	San Francisco, California
Lees, Charles E.....	Butte, Montana
Lyden, Joseph.....	Butte, Montana
MacPherson, Frank H.....	Butte, Montana
McMahon, Brandon.....	Butte, Montana
Ternouth, Blaine.....	Butte, Montana

FRESHMAN CLASS.

Aline, Peter A.....	Great Falls, Montana
Bresnahan, John.....	San Francisco, California
Daum, Willard W.....	Meaderville, Montana
Grupe, Gustave D.....	Vancouver, B. C.
Hansen, Beedie C.....	Moscow, Idaho
Kroger, Will.....	Butte, Montana

Nuckolls, Friel.....	Butte, Montana
Reber, Bert A.....	Butte, Montana
Spiegel, Sam.....	Butte, Montana
Walsh, Thomas F.....	Anaconda, Montana
Woodworth, Guy.....	Great Falls, Montana

SPECIAL STUDENTS.

Covington, Claude W.....	Seattle, Washington
Deusenbery, Vincent F.....	Bozeman, Montana
Emery, J. A.....	Butte, Montana
Evans, Vivian W.....	Butte, Montana
Irwin, Wilbur W.....	Portland, Oregon
Madson Frank W.....	Racine, Wisconsin
McAuliffe, Walter.....	Butte, Montana
Naughten, Alice M.....	Butte, Montana
Parkhurst, F. H.....	Butte, Montana
Pratt, A. F.....	Golden, Colorado
Scott, Clarence R.....	Empire, Colorado
Small, Walter S.....	Butte, Montana
Smith, Roy M.....	Cedar Rapids, Iowa
Tunnell, H. R.....	Butte, Montana

REGISTER OF ALUMNI.

CLASS 1903.

Bender, Louis V.....Anaconda, Montana
Supt. Blast Furnaces, Washoe Smelter.

CLASS 1904.

Balmforth, Alfred J.....Bisbee, Arizona
 Duling, Fred J.....Los Angeles, Cal
Supt. Pacific-American Development Co.
 Irelan, Arthur J.....Helena, Montana
Mining Engineer.
 Kuphal, Henry E.....Missoula, Montana
Mining Engineer.
 MacRae, Lachlan D.....Nacozari, Sonora, Mexico
Engineer, Moctezuma Copper Company.
 McGee, John.....Dale, California, via Amboy
General Manager Greenwater Copper Mines & Smelter Co.
 Pauly, P. L.....
 Reese, Clara Clark.....Denver, Colorado
 Stevenson, Isabel Little.....Newburg, W. Virginia
 Tallant, H. S.....Manatee, Florida

CLASS 1905.

Archibald, George B.....Helena, Montana
Mineral Inspector, G. F. O.
 Brinton, Owen F.....Kingman, Arizona
General Manager Arizona Alpha Mining Co.
 Corey, Clarence R.....Seattle, Washington
Instructor in Metallurgy, College of Mines, University of Washington.
 Duthie, John M.....Libby, Montana
County Surveyor.
 Elford, Basil.....Tonopah, Nevada
Assayer, Tonopah Extension Mining Co.
 Mackel, Louis.....Butte, Montana
Mining Engineer.
 Pratt, Paul D.....Libby, Montana
Mining Engineer.
 Stevenson, L. C.....Newburg, W. Virginia
Supt. Hamilton Coal & Coke Co.
 Van Gundy, Jay.....Bluff, Utah
Mgr. Pioneer Development Co., San Juan Oil Fields.

CLASS 1906.

Dugan, J. F.....Butte, Montana
Engineer, Anaconda Copper Mining Co.
 Feeney, Charles W.....Butte, Montana
Shiftboss, Badger State Mine, A. C. M. Co.
 Geiser, Herbert S.....Johannesburg, South Africa
Engineer, Breakepan Mining Company, Ltd.

Johns, John W.....	Amazon, Montana
<i>General Supt. Robert Emmet and Blue Bird Mines.</i>	
Kane, L. M.....	Butte, Montana
<i>Foreman, Berkeley Mine, A. C. M. Co.</i>	
Warfield Hershel.....	Los Angeles, Cal.
Wilson Bert T.....	Seattle, Washington
<i>Consulting Engineer, Mtn. Lake Power & Irrigation Co.</i>	
<i>City Engineer, Goldendale, Washington.</i>	
Young, Arthur B.....	Hamburg, Arizona
<i>Engineer, Hartford-Arizona Copper Mining Co.</i>	
Young, Siegfried A.....	Hamburg, Arizona
<i>Supt. Hartford-Arizona Copper Mining Co.</i>	

CLASS 1907.

Adami, Arthur.....	Butte, Montana
<i>Assistant Professor of Mining Engineering, Montana State School of Mines</i>	
Bovett, C. A.....	Mason, Nevada
<i>Mining Engineer, Mason Valley Mines Co.</i>	
McCracken, R. M.....	Bingham, Utah
<i>With Utah Consolidated Mining Co.</i>	
Reardon, D. J.....	Missoula, Montana
<i>Assistant City Engineer.</i>	
Schafer, W. A.....	Metcalf, Arizona
<i>Engineer, Arizona Copper Company.</i>	

CLASS 1908.

Bowden, Malcolm.....	Elkhorn, Montana
<i>Engineer, Elkhorn Silver Mining Company.</i>	
Ellis, Willis H.....	Butte, Montana
<i>Assistant City Engineer.</i>	
Foote, Frank A.....	Delta, Utah
Ketcham, S. H.....	Hamilton, Montana
<i>Engineer, Bitter Root Valley Irrigation Co.</i>	
Lomas, E. P.....	Butte, Montana
<i>Boss Trammer, Tramway Mine, A. C. M. Co.</i>	
Lowry, Thomas M.....	Butte, Montana
<i>Engineer, Butte Electric & Power Co.</i>	
McLaughlin, William D.....	Butte, Montana
<i>Surveyor, Tramway Mine, A. C. M. Co.</i>	
Meiklejohn, Archie B.....	La Luz, Guanajuato, Mexico
O'Brien, Albert.....	Butte, Montana
<i>Mining Engineer with Barker & Wilson.</i>	
Patten, Earle B.....	Anaconda, Montana
<i>Surveyor, Butte, Anaconda & Pacific Railway.</i>	
Proctor, I. O.....	Butte, Montana
<i>Sampler, Tramway Mine, A. C. M. Co.</i>	
Proctor, M. D.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Schiffner, O. E.....	Dale, Cal., via Amboy
<i>Engineer, Greenwater Copper Mines & Smelter Co.</i>	

Villars, Jesse R.....	Great Falls, Montana
<i>President, Villars-Barnum Engineering Co.</i>	
Walton, Lee M.....	Butte, Montana
<i>Engineer, Anaconda Copper Mining Co.</i>	
Wren, Andrew A.....	Hayden, Arizona
<i>Foreman of Concentrator, Ray Consolidated Copper Co.</i>	

CLASS 1909.

Brulo, William.....	Helena, Montana
<i>Deputy State Land Agent for Montana.</i>	
Evans, James R.....	Kinchassa, Congo, West Africa
<i>Formanier.</i>	
Gilham, Ralph E.....	Radersburg, Montana
<i>Engineer, Keating Gold Mining Co.</i>	
Haines, Peter A.....	Butte, Montana
<i>Sampler, Bell Mine, A. C. M. Co.</i>	
Johnstone, J. Clark.....	Jerome, Arizona
<i>Engineer, United Verde Copper Co.</i>	
Kane, Edward G.....	Butte, Montana
<i>Engineer, Anaconda Copper Mining Co.</i>	
Kirby, Kenneth.....	Butte, Montana
<i>Engineer, Anaconda Copper Mining Co.</i>	
Loughran, Michael.....	Butte, Montana
<i>Engineer, Anaconda Copper Mining Co.</i>	
Malloy, Edward F.....	Butte, Montana
<i>Sampler, Bell and Diamond Mines, A. C. M. Co.</i>	
Peters, Ira B.....	Butte, Montana
Stockett, Norman A.....	Gow Ganda, Ontario, Canada
<i>Supt. Willing Mining Co., Ltd.</i>	
Weigenstein, Henry J.....	Butte, Montana
<i>Mining Engineer.</i>	
Young, William A.....	Maiden, Montana
<i>Mine Foreman, Maginniss Mine.</i>	

CLASS 1910.

Grunert, August.....	Butte, Montana
<i>Chemical Department, A. C. M. Co.</i>	
Jensen, Walter H.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Stuewe, William Jr.....	Helena, Montana
<i>Mining Engineer.</i>	

CLASS 1911.

Clinch, R. S.....	Nacozari, Sonora Mexico
<i>Engineer, Moctezuma Mining Co.</i>	
McElvenny, L. T.....	Nacozari, Sonora, Mexico
<i>Engineer, Moctezuma Mining Co.</i>	
Murphy, James K.....	Anaconda, Montana
<i>Testing Engineer, Washoe Smelter, A. C. M. Co.</i>	
O'Connor, C. H.....	Dan Creek, Alaska
<i>Engineer, Alaska United Exploration Co.</i>	

Peterson, P. E.....	Butte, Montana
<i>Metallurgical Engineer, Butte & Superior Copper Co.</i>	
Roach, J. C.....	Wallace, Idaho
<i>Assayer, Success Mine.</i>	
Shields, E. Floyd.....	Butte, Montana
<i>Engineer, Butte & Superior Copper Co.</i>	
Sultzner, H. Duke.....	Butte, Montana
<i>Sampler, J. I. C. and Belmont Mines, A. C. M. Co.</i>	
Tout, Charles.....	Wallace, Idaho
<i>Surveyor, Success Mine.</i>	
Zentner, Arthur.....	Anaconda, Montana
<i>Testing Engineer, Washoe Smelter, A. C. M. Co.</i>	

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MONTANA STATE SCHOOL OF MINES

BUTTE, MONTANA

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MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

TWELFTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1912-1913

WITH ANNOUNCEMENTS FOR THE YEAR
1913-1914

CALENDAR FOR 1913-1914.

1913.

September 2, First Semester begins.

October 24, Close of First Term.

October 27, Second Term, First Semester begins.

November 27 and 28, Thanksgiving Recess.

December 19, End of First Semester.

1914.

January 5, Second Semester begins.

March 20, End of First Term, Second Semester.

March 23, Second Term, Second Semester begins.

June 5, Commencement Day.

September 8, First Semester begins.

1913.	1914.	1915.
JULY	JANUARY	JANUARY
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AUGUST	FEBRUARY	FEBRUARY
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SEPTEMBER	MARCH	MARCH
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OCTOBER	APRIL	APRIL
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NOVEMBER	MAY	MAY
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DECEMBER	JUNE	JUNE
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BOARDS OF CONTROL.

STATE BOARD OF EDUCATION.

MEMBERS EX-OFFICIO:

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President of the Board.

H. A. DAVEE, Superintendent of Public Instruction.
Secretary of the Board.

D. M. KELLY, Attorney General.

S. D. LARGENT

W. S. HARTMAN

JOHN DIETRICH

J. C. SMITH

C. H. HALL

N. R. LEONARD

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OSCAR ROHM.

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GEORGE W. CRAVEN, B. S.,
Professor of Mathematics and Mechanics.

THEODORE SIMONS, E. M., C. E.,
Professor of Mining Engineering.

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Professor of Geology and Mineralogy.

LESTER J. HARTZELL, E. M.,
Professor of Chemistry.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Assistant Professor of Mining Engineering.

E. B. YOUNG, A. M.,
Assistant Professor in Mathematics and Mechanics.

CHARLOTTE RUSSELL,
Librarian and Registrar.

M. F. HALEY,
Assistant Millman.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It is a significant date, as it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public-spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the grounds overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given this locality such publicity that no one now needs to be told of its leading position in the mining world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city are being enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the extensive mining and metallurgical plants in the vicinity of the School.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter, the opportunity is here presented for daily observation of works, the develop-

ment and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the School under the guidance of instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the School. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The library is located in a large, well-lighted room, which is always open to the students. The room is maintained by a librarian and offers with its alcoves a convenient and quiet place for the students' study hours. The fourth floor is given up mainly to museums containing extensive collections of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with requisite cabinets of rock specimens, thin sections, etc.; the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now in practice, a detailed account of which may be found

under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gymnasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may also be used as a general auditorium on special occasions. Connected with the gymnasium are two parlors, a dressing room, and in the basement a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1915, is \$33,000 per year.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The school is, therefore, wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed

by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for the work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which he comes.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

LIST OF ACCREDITED SCHOOLS IN THE STATE.

OF MONTANA.

City High Schools.

Anaconda	Forsyth	Helena
Billings	Columbus	Havre
Butte	Fort Benton	Virginia City
Chinook	Great Falls	

County High Schools.

Beaverhead, Dillon	Granite, Philipsburg
Broadwater, Townsend	Jefferson, Boulder
Carbon, Red Lodge	Missoula, Missoula
Custer, Miles City	Park, Livingston
Dawson, Glendive	Powell, Deer Lodge
Fergus, Lewistown	Sweet Grass, Big Timber
Flathead, Kalispell	Teton, Chouteau
Gallatin, Bozeman	

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order, and the balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR.

General Chemistry and Qualitative Analysis.....	\$15.00
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SOPHOMORE YEAR.

Surveying	\$10.00
Quantitative Analysis	15.00
Mineralogy	10.00
Deposit for Platinum Ware.....	30.00

JUNIOR YEAR.

Mine Surveying	\$10.00
Metallurgy	10.00

SENIOR YEAR.

Metallurgy and Assaying.....	\$15.00
Petrography	10.00

When the breakage exceeds the deposit the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY.

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	6	6
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	9	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Analytical Geometry	5	5
Plane Surveying, Theory.....	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	9	9
Mechanical Drawing	6	6

SOPHOMORE YEAR.

FIRST SEMESTER.

	First Term		Second Term
	Hours per week.		Hours per week.
Calculus	5	.....	5
Physics	6	.....	6
Chemistry, Lectures	2	.....	2
Mineralogy, Lectures	2	.....	2
Mineralogy, Laboratory	0	.....	6
Surveying, Field Work.....	15	.....	0
Topographical Drawing	0	.....	9

SECOND SEMESTER.

	First Term		Second Term
	Hours per week.		Hours per week.
Calculus, Anal. Mechanics....	5	.....	5
Physics	4	.....	4
Chemistry, Lectures	1	.....	1
Chemistry, Laboratory	9	.....	9
Mine Surveying, Theory	2	.....	2
Mineralogy, Lectures	3	.....	0
Geology, Lectures	0	.....	3
Mineralogy, Laboratory	6	.....	6

JUNIOR YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice.....	15	0
Chemistry	0	6
Graphics	0	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics and Hydraulics....	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	6
Geology, Field Work.....	3	3
Metallurgy, Laboratory	3	3
Chemistry Laboratory	3	3

SENIOR YEAR.

FIRST SEMESTER.

	First Term	Second Term
	Hours per week.	Hours per week.
Geology	5	5
Mining	2	2
Ore Dressing, Lectures.....	0	3
Metallurgy	3	2
Power Transmission	3	3
Assaying	15	0
Geology, Field Work	0	3
Ore Dressing, Laboratory....	0	3
Engineering Design	0	6

SECOND SEMESTER.

	First Term	Second Term
	Hours per week.	Hours per week.
Mining	3	3
Ore Dressing Lectures.....	2	2
Ore Dressing, Laboratory....	3	3
Metallurgy, Lectures	3	3
Metallurgy, Laboratory	3	3
Mechanical Engineering	5	5
Engineering Design	6	6
Petrography	5	5
Mining Law	5	0

ENGLISH.

Two hours per week during the first semester of the Freshman year are allotted to the study of English composition. The work is designed to review and continue the training outlined in the usual high school course, and to create and develop an individual and effective means of expression for the ordinary demands of professional life.

The work consists of a series of classroom lectures and discussions in which special attention is paid to the application of the principles of unity, coherence, and emphasis which characterize all good writing. These principles are applied to the word, the sentence, the paragraph and to the composition as a whole. Weekly themes required from the students, give excellent practice in correct grammar, punctuation, sentence structure, and the right choice of words. Numerous selections from books by the best writers and from the standard technical magazines are reviewed with the idea of studying and cultivating literary style. Text used is "English Composition in Theory and Practice," by Canby and others.

The study of English is by no means completed during this first half year. During the Junior and Senior years many reports on various phases of work in Geology, Ore Dressing, Smelting and Mining are required from the students. These reports must be carefully written, with due attention to all the principles of good usage in such matters, and serve as valuable training to the students.

Freshman, first semester, two hours per week.

MATHEMATICS.

PROFESSOR CRAVEN, ASST. PROFESSORS ADAMI AND YOUNG.

Algebra.—A preliminary course is first given designed to drill the student in the fundamental algebraic operations and in the statement and solution of simple mechanical problems. This review is followed for the remainder of the semester by a careful study of those operations of advanced algebra which will be of use to the student in future engineering courses. Special attention is given to the theory and use of exponents and logarithms, simultaneous quadratic equations, the more common series with their practical applications, indeterminate coefficients and quantics solved by synthetic division and by graphical methods. Text, Wentworth's College Algebra.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and

oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—This course from its very nature becomes a thorough review of algebra, geometry, and trigonometry. The material gathered from these three sources is combined in a most striking way which leads to a more practical working knowledge of these branches of mathematics. The student is required to study and plot accurately several hundred problems covering such topics as, the point and straight line in a plane, different systems of co-ordinates, conic sections, higher plane curves, the point and straight line in space, curved surfaces, and surfaces of revolution. Toward the end of the course the student is required to study various mechanical movements, to invent movements and to determine the laws and equations involved. Text Wentworth's Analytical Geometry.

Freshman, second semester, five hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maxima and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia, and work. The text used is Taylor's Differential and Integral Calculus.

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR BARD.

The geologic side of engineering is presented to the student through courses in Mineralogy, Geology and Petrography.

Mineralogy.—Text book is Rogers' "Study of Minerals." The purpose of this course is to familiarize the student with about three hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blowpipe Analysis, and by comparison with known mineral specimens. Thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarizing the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other chemical tests of importance in mineralogy. The optical mineralogy of mineral fragments is studied with petrographic microscopes.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. The introductory lectures take up the characters of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.

Sophomores, first semester, second term, eight hours per week.

Sophomores, second semester, first term, nine hours per week.

Sophomores, second semester, second term, six hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Chamberlain and Salisbury's "College Geology."

Sophomores, second semester, second term, three hours per week.

Juniors, first semester, five hours per week.

Juniors, second semester, first term, eight hours per week.

Economic Geology.—This course is devoted to a study of the more important economic deposits of the world, both metallic and non-metallic, with reference to their occur-

rence, geologic relations, origin and commercial value. The last term of the Junior year is devoted to the non-metallic minerals, and the first term of the Senior year to the metallic minerals. Field trips are made to mines and quarries to supplement the lecture work. The text book used is Ries' "Economic Geology," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.

Seniors, first semester, first term, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—An optional course in microscopical petrography is provided for the senior year. The principles and objects of the use of the microscope are outlined in an earlier course. This optional course in microscopical work is designed for students who intend to specialize in geology. Winchell's "Elements of Optical Mineralogy" is used for reference. The student is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Optional, Seniors, second semester, five hours per week.

CHEMISTRY.

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principles of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to another, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from text-book references, and it is essential for those who take the course to take notes on the lectures which are designed

to aid and direct the work performed in laboratory practice during the semester. The text book used is "Principles of Chemistry" by Kahlenberg.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

Freshmen, first semester, six hours per week.

Freshmen, second semester, nine hours per week.

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

Freshmen, second semester, three hours lecture per week.

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such as, analysis of limestone, dolomites, rock analysis, ores of iron, magnese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, fine dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and laboratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these practical features are employed the instructor bears it ever in mind that through all the work the student must be required

to use his own talents and learn to think and reason for himself.

Sophomores, first semester, two hours lecture per week.

Sophomores, second semester, one hour lecture per week.

Juniors, second term, first semester, six hours per week.

Fire Assaying.—The course in fire assaying is essentially a laboratory drill course. It comes during the Junior and Senior years when the students are already familiar with the reagents and most of the chemical reactions used in the work. However, the laboratory work is preceded by a short course in lectures in which the general principles of the art are developed and all equipment carefully explained. Attention is given to the proper care of the furnace and method of controlling the temperature. The special balances used in this work are demonstrated showing methods of operating, care and adjustments. Finally the class is given a series of notes which embody a description of the charges in actual use in the mining and smelting plants of the West.

In the laboratory work each student is given a desk with a full equipment of reagents and apparatus. Ample furnace room, balances and ore-grinding apparatus are provided so no delays are encountered through lack of equipment. Then each student works through his individual list of ores to be assayed. There are silicious oxidized ores, basic oxidized ores, ores of lead, copper and zinc; all containing various impurities. These are assayed for gold and silver and when lead is present it is also determined. The smelter products likewise receive attention; lead and copper mattes, speiss, antimonial lead, lead and copper bullion, lead and copper slags are all treated according to the custom about the laboratory of the smelter.

Both crucible and scorification methods are used where considered practicable, while the combined wet and dry methods are used upon material such as copper bullion, mattes high in copper, blister copper, etc.

The laboratory work covers about ten weeks of five afternoons each week. Throughout the course speed and accuracy are considered essential points. Before a student is considered proficient he must be able to accomplish what may be considered a reasonably day's work in a commercial laboratory. Accuracy is required, but it is not sufficient, the time is considered equally important.

In this course no charge is made for materials or equipment except where there is an unnecessary breakage or consumption of material.

Senior, first semester, first term, five afternoons per week

METALLURGY.

PROFESSOR BOWMAN, MR. HALEY.

Introduction to Metallurgy.—The study of metallurgy begins with lectures and recitations on the fundamental principles of the science. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, products of combustion, etc., are studied. The various fuel, solid, liquid and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast reverberatory, muffled and electric, used in metallurgical operations are described. In connection with this the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations observed is required of each student. The text book used is Peter's Practice of Copper Smelting.

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver.—The second semester of the junior year is devoted to the metallurgy of gold and silver. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The

other metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiviation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Silver.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments submitting a written report of the examinations made at the works.

Senior, first semester, three hours per week.

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through

references to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

Metallurgy Laboratory.—During one semester of the Junior year the class spends one afternoon per week conducting laboratory experiments which illustrate the principles and chemical reactions studied in the class room. There are experiments in roasting which are conducted so as to yield quantitative results in regard to formation of oxides, sulphates, etc. The more delicate problems of roasting which involve chloridizing various ores are also carried out. In these experiments all the important reactions are produced and observed. During the course each student makes up a series of slags and determines their melting points, viscosity, etc. During the work requiring the use of the furnace, a familiarity with the various types of pyrometers is obtained. The latter part of the semester is taken up with an analysis of fuels, this work includes the determination of the calorific power of the fuels by means of the bomb and the Parr calorimeters. The analysis of fuel gases and flue gases are carried out by the Hempel apparatus and by means of some of the more simple units where a complete analysis is not required.

Junior, second semester, one afternoon per week.

Metallurgy Laboratory.—The work of the last semester of the Senior year includes the testing of ores on a commercial scale. For this work ore of various kinds and grades are collected in the ore bins of the School's mill. From this point it is sampled and analyzed by the students and a proposed scheme of treatment laid out. A small sample is then tested according to the scheme submitted. For this work each student is given a regular chemical desk and has access to the special equipment required in concentrating, such as small classifiers, jigs and tables, and such equipment as is required for the lixiviation processes including small agitation vats, filters, etc.

Among the tests may be mentioned any of the processes of concentration requiring trommels, classifiers, jigs, tables, vanners, wet and dry screens, dewatering devices, etc. For this work there are crushers, rolls, mills, etc., so arranged as to reduce the handling of the ore by hand to a minimum. A battery of three stamps offers practice in stamp milling during which tests the class is given practice in dressing the plates and recovering the bullion. Other tests involve amalgamating pans, cyanide vats, of five tons capacity, a slime and agitation equipment, a lead-lined agitation barrel, etc. There are also large roasting furnaces with which any of the roasting operations may be carried out that are required in the standard processes of ore treatment.

During this work much attention is given to the handling and adjusting of machinery. Under proper instruction the students operate the mill from the power plant to the end. This experience is a valuable asset to any young engineer undertaking work, especially with the smaller plants of the West.

Senior year, second semester, one afternoon per week.

MECHANICS.

PROFESSOR CRAVEN, ASSISTANT PROFESSOR YOUNG.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text book used is Elements of Mechanics, by Merriman.

Sophomore, first semester, six hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and

heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Elementary Lessons in Electricity and Magnetism, by Jackson, is used as a text book.

Sophomore, second semester, four hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc. Merriman's *Mechanics of Materials* is used as a text book.

Junior, first semester, three hours per week; second semester, two hours per week.

Applied Mechanics.—It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, supports for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application to mining machinery is found in the catalogues furnished by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte.

Junior, first semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the West. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's *Treatise on Hydraulics* is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power house are also made a part of this course. The text book used is *Steam Engines and Boilers*, by Kinealy.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr.

Senior, first semester, three hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted as to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmission, power transmission by continuous current, some properties of alternating currents, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the Junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structure intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due to a locomotive, also stresses due to the wind, etc. The work

is carried out in the drawing room, supplemented by lectures and recitations. Steel Mill Buildings, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Senior, first semester, first term, nine hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; constructions of retaining walls, foundations, dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum's Steel Mill Buildings.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN.

PROFESSOR CRAVEN, ASSISTANT PROFESSOR ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The student should consult the instructor in charge in regard to the kind and number of instruments necessary.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshman, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subject laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is

taught the use of water colors as applied to engineering drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, head frames and machine drills with the conventions used in mine and geological maps, and many other useful items used in mining.

Freshman, second semester, six hours per week.

Descriptive Geometry.—Two hours per week throughout the Freshman year are occupied with recitations in descriptive geometry. Throughout the course the students study assigned lessons from a text book, together with the notation work, etc. The class period is taken up for the most part with the working of new problems, especially those involving the point, line, and plane; it is a drill hour in rapidity and accuracy in the application of the essential features of the subject. The procedure insures a thorough mastery of all the elements, an acquisition which is of great value in much of the work of the mining engineer. It assists him in his mechanical drawing and designing, it is indispensable in many problems in mine surveying and aids greatly in part of the work in geology especially in the practical work in mines where faults and veins are traced and platted.

In the latter part of the work where the more complicated intersections of solids and the developments of surface are required, the class works in the drawing room. Here the problems are likewise varied so that the possibility of merely copying or committing to memory is eliminated. The course follows in close touch with the regular mechanical drawing where the more elaborate drawings are completed, dimensioned and inked. The text used is Faunce's Descriptive Geometry.

Freshman year, two hours per week.

Machine Design.—This course is an application of the material presented in the second course in applied mechanics. The object is to give instruction in machine drawing so that repair parts for hoists, crushers, rolls, stamps, etc., may be correctly designed and represented. Attention is given to conventions, sections, correct lettering, and dimensioning. The problems are given entirely by dictation. Machine Design, by Low and Bevis, and Kent's Mechanical Engineer's Hand Book are used as reference books. Several copies of these volumes are to be found on the tables of the drawing room.

Junior, first semester, second term, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Plane Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requiring a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Mine Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating quantities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Plane Surveying, Field Work.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Determination of elevations by aneroid barometer. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Sophomore, first semester, first term, fifteen hours per week.

Mine Surveying, Field Work.—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles,

calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shift by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the coordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods.

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the Sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, second term, six hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mine where mining operations are observed.

Junior, first and second semester, two hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Junior, second semester, two hours per week.

Air Compression.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, first semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, six hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Study of the construction and operation of typical milling machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, first hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general offices. The problems with all conditions and requirements

are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week

MINING LAW.

JUDGE EDWARD B. HOWELL OF THE MONTANA BAR.

A course of instruction on the law relating to mining claims, including the method of acquiring title from the United States to lode, placer, tunnel and mill-site claims in the various states and Alaska, with a comparative study of federal and state laws on the subject, the law relating to extra-lateral rights, leases, options to purchase, conveyances of mining claims, and water rights, the relative rights of citizens and aliens in the tenure of mining claims. The object of the course is to give the student a good working knowledge of mining law, and to this end students are required to draft location notices and similar instruments that might become necessary in their work in the field. Through the recitations the class is given a thorough drill in rights of the locator also in ways in which these rights may be transmitted or may be forfeited, all principles being abundantly illustrated by actual and hypothetical cases. Questions of more complexity are illustrated by elaborate models and charts, many of these models were constructed to represent the claims of mining companies in the courts.

The course in Mining Law consists of lectures and recitations covering a period of two months and is required of the Senior class. The class uses as a text book for this course Mr. Howell's manual on "Lode and Placer Claims."

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the School. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. The department is furnished with large recitation and lecture rooms on the first floor, abundantly supplied with blackboard space, terrestrial and celestial globes, some simple models, and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qual-

itative and quantitative analysis, one for metallurgy, and two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accomodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of the student in the laboratories. These balances are placed on stands which rest on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the students in the laboratories and all check analyses on the students' work are made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast

and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces and one gasoline furnace, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a buckboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold and silver ores, together with mattes, both copper and lead, slag, flue-dust, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for the hypo sulphite treatment. There are arrangements for treating free milling gold

ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gasses of combustion, reverberatory and blast furnace, illuminating gasses, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

MINING, ORE DRESSING, AND METALLURGY.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing-boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following instruments have been provided: Ten engineering transits; one from Buff and Buff, two from C. L. Berger & Sons,

four from Gurley, one from Keuffel and Esser, one from Young & Son, and one from Eugene Dietzgen. Five levels—one from Buff, one from Gurley, two from Keuffel and Esser, one from Berger, and one from Young & Son. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plummets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four-foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

An equipment for making cyaniding tests provides for leaching ores in five-ton lots. In this plant sands and slimes may be separated, dewatered and treated separately. There are five vats and two sump tanks, one steel tank provided with air and mechanical agitators. All necessary filters, zinc boxes, etc., for making commercial tests are installed for use in this plant.

A pan amalgamation plant consists of a Bruckner chloridizing furnace, a pan amalgamator and settling tank. All the usual equipment, such as steam, launders and utensils, etc., are at hand for the convenient working of this plant.

The laboratory contains a Wedge furnace designed to be used as a reverberatory or a muffle furnace. This furnace is mechanically rabbled and used in roasting ores in lots of one ton or more. There is also a lead-line agitation barrel provided for experiments involving this type of apparatus.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs. Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four hundred pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its

travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Boston & Montana concentrator at Great Falls, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other States.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and

methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies five rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the museums, the petrographic laboratory, dark room and storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of a rarer, the larger and the more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geological and areal maps. The dark room on the third floor contains apparatus and chemicals

for photographic work. The storage room on the same floor contains materials for exchange, etc.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercises. In addition to these real crystals, four series of crystal models are available, two of wood, one of celluloid and one of glass. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Twenty-two large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, specimens illustrating geologic structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to the Dana classification. A collection of one hundred and sixty gold crystals is kept on exhibition in the library. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collections contain over one thousand specimens. The museum in all contains over ten thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommodating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers Westphal balances, Plattner scales, burettes, agate mortars and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here will also be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analyses of minerals and rocks.

The working paleontological collection consists of over two thousand catalogued fossils, systematically arranged in files of drawers in the office of the department.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels, aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography.—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and two of them, one Leitz and one Nachet, are of a larger size than the others, and are equipped with accessories for research work. The School has purchased from Fuess a very fine projection apparatus which is provided with a large

petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the museum contains five hundred slides of minerals, six hundred thin sections of rocks, and one hundred slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are nearly all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with his microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a wire and also with a wheel, both for cutting slides. Emery, Canada balsam, hick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room con-

veniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

An engine and dynamo laboratory is located in the basement of the building; there is installed here a gas engine of ten horsepower for experimental purposes. A ten horsepower three phase induction motor drives direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. It is charged from the direct current dynamo or mercury arc rectifier. The requisite voltmeters and ammeters for both alternating and direct currents, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

The power plant for the mill contains two 80 horsepower boilers, a 75 horsepower high speed engine belted

to a 50 K. W., three-phase generator with switchboard and necessary instruments, and an air compressor with steam cylinders 8-inch by 10-inch and air cylinders $7\frac{1}{2}$ -inch and 13-inch by 10-inch.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subject to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building, its windows facing the main range of the Rocky Mountains and overlooking the famous Anaconda Hill. It is a large, well-lighted room and offers with its alcoves a convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others is nearly 9,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; and Engineering Corps. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, geological and literary magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers, and periodical issues of other colleges.

LIST OF STUDENTS.

 SENIOR CLASS.

Crittenden, Zar T.....	Mount Pleasant, Michigan
Dobson, Chris G.....	Seattle, Washington
Hanson, Wilbur W.....	Butte, Montana
McCool, Edward J.....	Butte, Montana
Manwaring, Joe H.....	Ann Arbor, Michigan
Newton, Lucian C.....	Butte, Montana
Pierse, Edwin A.....	Great Falls, Montana
Pratt, A. F.....	Portland, Oregon
Reid, Milton A.....	Anaconda, Montana

JUNIOR CLASS.

Baker, Jacob.....	Butte, Montana
Cole, Robert J.....	Seattle, Washington
Goodell, L. T.....	Seattle, Washington
Lyden, Joseph P.....	Butte, Montana
McMahon, Brandon.....	Butte, Montana
MacPherson, Frank H.....	Butte, Montana
Murphy, Joseph G.....	Seattle, Washington
Ternouth, Blaine.....	Butte, Montana
Watson, Robert I.....	Park City, Utah

SOPHOMORE CLASS.

Aline, Peter.....	Great Falls, Montana
Amidon, Richard G.....	Minneapolis, Minnesota
Bresnahan, John.....	San Francisco, California
Daum, Willard W.....	Meaderville, Montana
Hunt, John E.....	Butte, Montana
Nuckolls, Friel.....	Butte, Montana
Reber, Bert A.....	Butte, Montana
Woodworth, Guy.....	Great Falls, Montana

FRESHMAN CLASS.

Goethke, Fred P.....	Butte, Montana
Hill, W. J.....	South Bend, Indiana
Hogan, Eugene.....	Butte, Montana
Kizer, Lloyd L.....	South Bend, Indiana

Lind, A. Leslie.....	Butte, Montana
Lyens, Thomas T., Jr.....	Butte, Montana
Mason, Veyne V.....	Helena, Montana
Peake, George T.....	Aberdeen, South Dakota
Simons, Walter W.....	Butte, Montana
Steele, Chester.....	Butte, Montana
Strang, Willis B	Musselshell, Montana

SPECIAL STUDENTS.

Brophy, T. D.....	Butte, Montana
Clark, Rupert.....	Red Deer, Alberta, Canada
Dodge, William E.....	Shawnee, Oklahoma
Grupe, Gustave.....	Lewistown, Montana
Naughten, Alice M.....	Butte, Montana

REGISTER OF ALUMNI.

CLASS 1903.

Bender, Louis V.....Anaconda, Montana
Assistant General Superintendent Washoe Reduction Works.

CLASS 1904.

Balmforth, Alfred J.....Organ, New Mexico
Vice-President and General Manager San Andreas Mining Co.
 Duling, Fred J.....Los Angeles, California
Superintendent Pacific-American Development Co.
 Irelan, Arthur J.....Helena, Montana
Mining Engineer.
 Kuphal, Henry E.....Andrade, California
Engineer and Inspector Concrete Construction.
 MacRae, Lachlan D.....Nacozari, Sonora, Mexico
Construction Engineer, Nacozari Railway.
 McGee, John.....Dale, via Amboy, California
General Manager, Greenwater Copper Mines and Smelter Co.
 Pauly, P. L.....
 Reese, Clara Clark.....Long Beach, California
 Stevenson, Isabel Little.....Newburg, West Virginia
 Tallant, Harry S.....Palma Sola, Florida
Farmer.

CLASS 1905.

Archibald, George B.....Salt Lake City, Utah
Carey Act and Mineral Inspector, General Land Office, Department of the Interior.
 Brinton, Owen F.....Gold Road, Arizona
*Superintendent Gold Road Mines Co.
 U. S. Smelting, Refining and Mining Co.*
 Corey, C. R.....Seattle, Washington
Instructor in Metallurgy, University of Washington.
 Duthie, John M.....Libby, Montana
Mining and Civil Engineer.
 Elford, Basil.....Tonapah, Nevada
Assayer, Tonapah Extension Mining Company.
 Mackel, Louis C.....Whitehall, Montana
Engineer.
 Pratt, Paul D.....Libby, Montana
Mining and Civil Engineer.
 Stevenson, L. C.....Newburg, West Virginia
Superintendent Virginia-Maryland Coal Corporation.

Van Gundy, J. E.....Bluff, Utah
Manager Pioneer Development Co., San Juan Oil Fields.

CLASS 1906.

Dugan, J. F.....Butte, Montana
Engineer, Anaconda Copper Mining Co.

Feeney, Charles W.....Butte, Montana
County Surveyor, Silver Bow County.

Geiser, Herbert S.....Johannesburg, South Africa
Engineer, Breakpan Mining Co. Ltd.

Johns, John W.....Wicks, Montana
General Superintendent Robert Emmet and Blue Bird Mines.

Kane, L. M.....Butte, Montana
Sampler, Anaconda, Never Sweat and St. Lawrence Mines, A. C. M. Co.

Warfield, Hershel.....Chicago, Illinois
Bonds, Mortgages and Stocks.

Wilson, Bert T.....Seattle, Washington
Consulting Engineer, Mtn. Lake Power & Irrigation Co.

Young, Arthur B.....Canille, Arizona
Mining Engineer.

Young, S. A.....Hamburg, Arizona
Superintendent Hartford-Arizona Copper Mining Co.

CLASS 1907.

Adami, Arthur E.....Butte, Montana
Assistant Professor of Mining Engineering, Montana State School of Mines.

Bovett, C. A.....Mason, Nevada
Mining Engineer, Mason Valley Mines Co.

McCracken, R. H.....Maxville, Montana
Mill Superintendent, Royal Basin Mining & Milling Co.

Reardon, D. J.....Butte, Montana
Deputy County Surveyor.

Schafer, W. A.....Metcalf, Arizona
Engineer, Arizona Copper Company.

CLASS 1908.

Bowden, Malcolm.....Melrose, Montana
Engineer, Hecla Mines.

Ellis, Willis H.....Butte, Montana
Field Assistant to City Engineer.

Foote, Frank A.....Delta, Utah
Farmer.

Ketcham, S. H.....Hamilton, Montana
Engineer, Bitter Root Valley Irrigation Co.

Lomas, E. P.....Butte, Montana
Assistant Surveyor Tramway Mine, A. C. M. Co.

Lowry, T. M.....Butte, Montana
Engineer Butte Electric and Power Co.

McLaughlin, William D.....	Butte, Montana
<i>Surveyor Tramway Mine, A. C. M. Co.</i>	
Meiklepohn, Archie B.....	La Luz, Guanajuato, Mex.
<i>Mining Engineer.</i>	
O'Brien, Albert.....	Butte, Montana
<i>Mining Engineer, Barker & Wilson Company.</i>	
Patten, Earle B.....	Philipsburg, Montana
<i>Mining Engineer.</i>	
Proctor, I. O.....	Butte, Montana
<i>Engineer, Elm Orlu Mining Company.</i>	
Proctor, M. D.....	Great Falls, Montana
<i>Chicago, Milwaukee & Puget Sound Ry. Co.</i>	
Schiffner, Otto E.....	Dale, via Amboy, Cal.
<i>Engineer, United Greenwater Copper Co.</i>	
Villars, Jesse R.....	Great Falls, Montana
<i>President, Villars-Barnum Engineering Co.</i>	
Walton, Lee M.....	Butte, Montana
<i>Foreman of Mill, Butte-Duluth Mining Co.</i>	
Wren, A. A.....	Douglas, Arizona
<i>With Repath & McGregor, Engineers.</i>	

CLASS 1909.

Brulo, William.....	Helena, Montana
<i>Deputy State Land Agent for Montana.</i>	
Evans, James R.....	Kinchassa, Congo, West Africa
<i>Formanier.</i>	
Gilham, Ralph.....	Radersburg, Montana
<i>Assistant Superintendent Keating Gold Mining Co.</i>	
Haines, Peter A.....	Rivermines, Missouri
<i>Assistant Superintendent Doe Run Lead Company.</i>	
Johnstone, J. Clark.....	Jerome, Arizona
<i>Engineer United Verde Copper Company.</i>	
Kane, Edward G.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Kirby, Kenneth P.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Loughran, Michael.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Malloy, Emmet E.....	Butte, Montana
<i>Mining Engineer.</i>	
Peters, Ira B.....	Butte, Montana
<i>Engineer, City Engineer's Office.</i>	
Stockett, Norman A.....	Gowganda, Ont., Canada
<i>Superintendent Willing Mining Company, Ltd.</i>	
Weigenstein, Henry J.....	Butte, Montana
<i>Shift Boss Diamond Mine, A. C. M. Co.</i>	
Young, William A.....	Maiden, Montana
<i>Member of Gold Reef Lease.</i>	

CLASS 1910.

Grunert, August.....	Butte, Montana
<i>Chemical Department, A. C. M. Co.</i>	
Jensen, Walter H.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Stuewe, William, Jr.....	

CLASS 1911.

Clinch, R. S.....	Nacozari, Sonora, Mexico
<i>Engineer, Moctezuma Mining Co.</i>	
McElvenny, L. T.....	Nacozari, Sonora, Mexico
<i>Engineer, Moctezuma Mining Co.</i>	
Murphy, James K.....	Anaconda, Montana
<i>Laboratory, Washoe Smelter, A. C. M. Co.</i>	
O'Connor, C. H.....	Butte, Montana
<i>Metallurgical Engineer, Butte & Superior Copper Co.</i>	
Peterson, P. E.....	Butte, Montana
<i>Metallurgical Engineer, Butte & Superior Copper Co.</i>	
Roach, James., died June 2, 1912.	
Shields, E. Floyd.....	Butte, Montana
<i>Mining Engineer, Butte & Superior Copper Co.</i>	
Sultzor, H. Duke.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Tout, Charles.....	Butte, Montana
<i>Mining Engineer, Cliff Mining Company.</i>	
Zentner, Arthur A.....	Butte, Montana
<i>Chemist, Washoe Smelter, A. C. M. Co.</i>	

CLASS 1912.

Andrew, John T.....	Notre Dame, Indiana
<i>Mining Law Student, Notre Dame University.</i>	
Bassett, Arthur F.....	Butte, Montana
<i>Sampler, Butte Reduction Works.</i>	
Christian, Otto B.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Clinch, W. D.....	Butte, Montana
<i>Sampler Speculator Mine, North Butte Mining Co.</i>	
Cohen, Jesse.....	Anaconda, Montana
<i>Assistant Engineer of Tests, Washoe Smelter, A. C. M. Co.</i>	
Cooke, Hamilton, Jr.,.....	Butte, Montana
<i>With Colusa-Parrot Ore Testing Plant.</i>	
Cullity, Emmet.....	Berkeley, California
<i>Engineering Department, Panama-Pacific International Exposition Co.</i>	
Fowler, George M.....	Butte, Montana
<i>Mining Engineer.</i>	
Gidel, Murl.....	Butte, Montana
<i>Assistant Geologist A. C. M. Co.</i>	

Giovanetti, Ettore.....	Butte, Montana
<i>Draftsman, Butte & Superior Copper Co.</i>	
Grupe, Charles.....	Libby, Montana
<i>Engineer with Paul Pratt.</i>	
Pilger, Theodore F.....	Butte, Montana
<i>Roach & Pilger, Real Estate and Mines.</i>	
Williams, Paul K.....	Butte, Montana
<i>Sampler, North Butte Mining Company.</i>	

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4

MONTANA STATE SCHOOL OF MINES

BUTTE, MONTANA

1914-15

MONTANA STATE
SCHOOL OF MINES

BUTTE, MONTANA

THIRTEENTH ANNUAL CATALOGUE

OF OFFICERS AND STUDENTS

FOR THE YEAR

1913-1914

WITH ANNOUNCEMENTS FOR THE YEAR

1914-1915

CALENDAR FOR 1914-15

1914

September 8, First Semester begins.
November 11, Close of First Term.
November 12, Second Term, First Semester begins.
November 26 and 27, Thanksgiving Recess.
December 24, Holiday Recess begins.

1915

January 4, Holiday Recess ends.
January 22, End of First Semester.
January 25, Second Semester begins.
March 31, End of First Term, Second Semester.
April 1, Second Term, Second Semester begins.
June 4, Commencement Day.
September 7, First Semester begins.

1914.		1915.		1916.									
JULY		JANUARY		JULY		JANUARY							
S	M	T	W	T	F	S	S	M	T	W	T	F	S
						</							

BOARDS OF CONTROL.

STATE BOARD OF EDUCATION.

MEMBERS EX-OFFICIO:

S. V. STEWART, Governor of the State,

President of the Board.

H. A. DAVEE, Superintendent of Public Instruction,

Secretary of the Board.

D. M. KELLY, Attorney General,

S. D. LARGENT

W. S. HARTMAN

JOHN DIETRICH

J. C. SMITH

C. H. HALL

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WARD H. NYE

O. W. McCONNELL.

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Secretary.

OSCAR ROHN

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Professor of Chemistry.

BANCROFT GORE, Ph. D.,
Professor of Metallurgy.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Assistant Professor of Mining Engineering.

CHARLOTTE RUSSELL,
Librarian and Registrar.

M. F. HALEY,
Assistant Millman.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It is a significant date, as it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agriculture and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public-spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the grounds overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given this locality such publicity that no one now needs to be told of its leading position in the mining world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city are being enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the extensive mining and metallurgical plants in the vicinity of the School.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter, the opportunity is here presented for daily observation of works, the develop-

ment and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the School under the guidance of instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the School. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The fourth floor is given up mainly to museums containing extensive collections of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with exquisite cabinets of rock specimens, thin sections, etc.: the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now in practice, a detailed account of which may be found under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the

school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gymnasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may also be used as a general auditorium on special occasions. Connected with the gymnasium are two parlors, a dressing room, and in the basement a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1915, is \$65,000.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The School is therefore wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week: two

laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for the work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which they come.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory

evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

ACCREDITED HIGH SCHOOLS OF MONTANA.

All the County High Schools are accredited. The following District High Schools are also accredited:
Anaconda

Anaconda	Forsyth	Moore
Belt	Glasgow	Plains
Billings	Great Falls	Polson
Butte	Hamilton	Pony
Chinook	Harlowtown	Stevensville
Columbus	Havre	Terry
Conrad	Helena	Victor
Eureka	Laurel	Virginia City
	Libby	Whitehall

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order, and the balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR.

General Chemistry and Qualitative Analysis.....	\$15.00
Surveying	10.00

SOPHOMORE YEAR.

Quantitative Analysis	\$15.00
Mineralogy	5.00
Deposit for Platinum Ware.....	30.00

JUNIOR YEAR.

Mining Surveying	\$10.00
Metallurgy	10.00

SENIOR YEAR.

Metallurgy and Assaying	\$15.00
Petrography	10.00

When the breakage exceeds the deposits the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the school. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY.

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	6	6
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	9	9

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Analytical Geometry	5	5
Plane Surveying, Theory.....	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	9	9
Mechanical Drawing	6	6

Plane Surveying, Field Work, Summer Course of Four Weeks

SOPHOMORE YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Chemistry Laboratory	6	9
Mineralogy, Lectures	2	2
Mineralogy, Laboratory	0	6
Topographical Drawing	9	0

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Calculus, Anal. Mechanics....	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory	2	2
Mineralogy, Lectures	3	0
Geology, Lectures	0	3
Mineralogy, Laboratory	6	6

JUNIOR YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice.....	15	0
Engineering Design	0	9
Graphics	0	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mechanics and Hydraulics....	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	3
Geology, Field Work.....	3	3
Assaying	6	6
Mining Laboratory	0	3

SENIOR YEAR.

FIRST SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Geology	5	5
Mining	2	3
Ore Dressing	0	2
Metallurgy	3	2
Mechanical Engineering	5	3
Geology, Field Work	0	3
Metallurgical Laboratory	15	6
Engineering Design	0	6

SECOND SEMESTER.

	First Term Hours per week.	Second Term Hours per week.
Mining	3	3
Ore Dressing	2	2
Metallurgy	3	3
Metallurgy Laboratory	6	6
Power Transmission	3	3
Engineering Construction	2	2
Engineering Design	6	6
Petrography	5	5
Mining Law	2	0

ENGLISH.

Two hours per week during the Freshman year are allotted to the study of English composition. The work is designed to continue the training outlined in the usual high school course, the chief aim being to create an individual and effective means of expression and communication for the ordinary demands of professional life. The ability to express oneself accurately and with some degree of elegance is an advantage which is not easily overestimated. At the same time the stimulating of literary sympathy and appreciation is kept in view, this we deem especially desirable in a professional course, as it supplies an element which is a source of pleasure in after life.

The work begins with a series of classroom lectures and discussions during which time the students are given simple exercises in writing; special attention is given to grammar, punctuation, choice of words, etc. Finally this work is extended to the study of the paragraph and the more complete theme.

During the latter part of the year the class is organized to develop the debate together with the regular theme writing. Proper form and fluency in speaking to an audience is a matter cultivated throughout the year. Among the other helpful features of the course may be mentioned a thorough and practical drill in parliamentary law, instruction on note taking, on making outlines, on writing examination papers and on the use of the library. The reading assignments for critical study are drawn mainly from the best technical magazines, from the best editorials, while occasionally a book of purely literary merit is assigned for review.

MATHEMATICS.

PROFESSORS CRAVEN AND BOWMAN, ASST. PROFESSOR ADAMI.

Algebra.—A preliminary course is first given designed to drill the student in the fundamental algebraic operations and in the statement and solution of simple mechanical problems. This review is followed for the remainder of the semester by a careful study of those operations of advanced algebra which will be of use to the student in future engineering courses. Special attention is given to the theory and use of exponents and logarithms, simultaneous quadratic equations, the more common series with their practical applications, indeterminate coefficients and quantics solved by synthetic division and by graphical methods. Text, Wenworth's College Algebra.

Freshman, first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and

oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—This course from its very nature becomes a thorough review of algebra, geometry, and trigonometry. The material gathered from these three sources is combined in a most striking way which leads to a more practical working knowledge of these branches of mathematics. The student is required to study and plot accurately numerous problems covering such topics as, the point and straight line in a plane, different systems of co-ordinates, conic sections, higher plane curves, the point and straight line in space, curved surfaces, and surfaces of revolution. Toward the end of the course the student is required to study various mechanical movements, to devise movements and to determine the laws and equations involved. Text, Wentworth's Analytical Geometry.

Freshman, second semester, five hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maxima and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia, and work. The text used is Taylor's Differential and Integral Calculus.

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR BARD.

The geologic side of engineering is presented to the student through courses in Mineralogy, Geology and Petrography.

Mineralogy.—Text book is Rogers' "Study of Minerals." The purpose of this course is to familiarize the student with about three hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blowpipe Analysis, and by comparison with known mineral specimens. Thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarize the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other tests of importance in mineralogy. The optical properties of mineral fragments are studied with petrographic microscope.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. The introductory lectures take up the characters of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.

Sophomores, first semester, second term, eight hours per week.

Sophomores, second semester, first term, nine hours per week.

Sophomores, second semester, second term, six hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Chamberlain and Salisbury's "College Geology."

Sophomores, second semester, second term, three hours per week.

Juniors, first semester, five hours per week.

Juniors, second semester, first term, eight hours per week.

Economic Geology.—This course takes up the principles of mineral disposition, both metallic and non-metallic. Geologic relations, commercial value and geographic distribution of the more important mineral districts are considered. Field

trips are made to mines and quarries to supplement the lecture work. The textbook used is Lindgren's "Mineral Deposits," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.

Seniors, first semester, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—A course in microscopical petrography is provided for the senior year. The principles and objects of the use of the microscope are outlined in an earlier course. This course in microscopical work is designed for students who intend to specialize in geology. Winchell's "Elements of Optical Mineralogy" is used for reference. The student is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Seniors, second semester, five hours per week.

CHEMISTRY.

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principles of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to another, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from text-book references, and it is essential for those who take the course to take notes on the lectures which are designed to aid and direct the work performed in laboratory practice during the semester. The text book used is "Principles of Chemistry" by Kahlenberg.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

*Freshmen, first semester, six hours per week.
Freshmen, second semester, nine hours per week.*

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

Freshmen, second semester, three hours per week.

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such as, analysis of limestone, dolomites, rock analysis, ores of iron, magnese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, flue dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and laboratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these practical features are employed the instructor bears it ever in mind that through all the work the student must be required to use his own talents and learn to think and reason for himself.

Sophomores, first semester, first term, two hours' lecture per week and six hours laboratory.

Sophomores, first semester, second term one hour lecture per week and nine hours laboratory.

Sophomores, second semester, one hour lecture per week and nine hours laboratory.

METALLURGY.

PROFESSOR GORE, MR. HALEY.

Introduction to Metallurgy.—The study of Metallurgy begins with lectures and recitations on the fundamental principles of the science. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gasses, products of combustion, etc., are studied. The various fuel, solid, liquid and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast reverberatory, muffled and electric, used in metallurgical operations are described. In connection with this the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation room, one week is devoted to a practical study of smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations observed is required of each student. The text book used is Peter's Practice of Copper Smelting.

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver.—The second semester of the junior year is devoted to the metallurgy of gold and silver. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The

other metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Silver.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments submitting a written report of the examinations made at the works.

*Senior, first semester, first term, three hours per week.
Senior, first semester, second term, two hours per week.*

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through references to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

Fire Assaying.—The course in fire assaying is essentially a laboratory drill course. It comes during the Junior and Senior years when the students are familiar with the reagents and most of the chemical reactions used in the work. However, the laboratory work is preceded by a short course in lectures in which the general principles of the art are developed and all equipment carefully explained. Attention is given to the proper care of the furnace and method of controlling the temperature. The special balances used in this work are demonstrated showing methods of operating, care and adjustments. Finally the class is given a series of notes which embody a description of the charges in actual use in the mining and smelting plants of the West.

In the laboratory work each student is given a desk with a full equipment of reagents and apparatus. Ample furnace room, balances and ore-grinding apparatus are provided so no delays are encountered through lack of equipment. Then each student works through his individual list of ores to be assayed. There are silicious oxidized ores, basic oxidized ores, ores of lead, copper and zinc; all containing various impurities. These are assayed for gold and silver and when lead is present it is also determined. The smelter products likewise receive attention; lead and copper mattes, speiss, antimonial lead, lead and copper bullion, lead and copper slags are all treated according to the custom about the laboratory of the smelter.

Both crucible and scorification methods are used where considered practicable, while the combined wet and dry methods are used upon material such as copper bullion, mattes high in copper, blister copper, etc.

The laboratory work covers about twenty weeks of two afternoons each week. Throughout the course speed and accuracy are considered essential points. Before a student is considered proficient he must be able to accomplish what may be considered a reasonable day's work in a commercial laboratory. Accuracy is required, but it is not sufficient, the speed is considered equally important.

In this course no charge is made for materials or equipment except where there is an unnecessary breakage or consumption of material.

Junior, second semester, two afternoons per week.

Metallurgical Laboratory Practice.—The work of the first term of the Senior year includes the systematic investigation of a large variety of commercial ores for the purpose of determining in each case the most economical metallurgical process for the recovery of the precious or base metals. In connection with this work the students have access to special laboratory equipment of the most approved appliances for ore testing on a miniature scale. Recent additions to this laboratory include a slide-testing machine for the study on a reduced scale of the oil-flotation process; a large porcelain

pebble mill for all-sliming operations, grinding in solution and chlorination work; special air agitation apparatus for the cyanide treatment of refractory ores and concentrates; individual vacuum filters and a small Kelly filter press for the study of problems involving slime filtration and washing.

A small lot of uncrushed ore, generally not less than fifty pounds is given to each student, who first makes a careful physical examination indicating the minerals containing the precious or base metals, those composing the gangue, nature of the ore and such characteristics as might have a bearing on the particular line of investigation to be followed. An accurate sample is then prepared, assayed and analyzed for the usual constituents determined in metallurgical practice. A scheme of treatment is then outlined and the results obtained are systematically tabulated, forming the basis of an individual report on the economical treatment of the ore in question.

Experience gained in previous years' work in mineralogy, assaying and metallurgical analysis is made frequent use of in this course and accordingly no student will be admitted unless qualified in these subjects.

Special emphasis will be given to processes of current interest open to important future developments such as refractory gold and silver ores and concentrates, oil flotation methods and hydrometallurgical treatment of copper ores. There is practice work in amalgamation, concentration, chloridizing roasting, hyposulphite leaching, magnetic separation and dry chlorination.

Seniors, first semester, first term, five afternoons per week.

Metallurgical Mill Practice.—Data obtained in the metallurgical laboratory during the first semester forms the basis of actual mill tests during the balance of the school year, the aim being to duplicate on a commercial scale the results previously obtained from laboratory samples.

For this work there are crushers, rolls, mills, etc., so arranged as to reduce the handling of the ore by hand to a minimum.

A battery of three stamps offers practice in stamp milling during which tests the class is given practice in dressing the plates and recovering the bullion. Other tests involve the use of amalgamating pans, cyanide vats of three tons capacity, a slime and agitation equipment, a lead lined agitation barrel for chlorination work. There are also roasting furnaces with which any of the roasting operations may be carried out that are required in the standard processes of ore treatment.

During this work much attention is given to the handling and adjusting of machinery. Under proper instruction the students operate the mill from the power plant to the tailings dump. This experience is a valuable asset to any young engineer undertaking work, especially with the smaller plants of the west, since mining engineers, even if they are not

metallurgists, are frequently called on to operate ore dressing or milling plants. The course also gives excellent opportunity for gaining experience in methods of sampling.

One hour each week is devoted to a discussion of the principles involved in each of the milling operations and individual reports are read and commented upon.

Seniors not electing Petrography during the second semester, devote the equivalent time to work in this course.

Seniors, first semester, second term, two afternoons per week

Seniors, second semester, two afternoons per week, conferences one hour per week.

MECHANICS.

PROFESSORS CRAVEN AND BOWMAN.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text book used is Elements of Mechanics, by Merriman.

Sophomores, first semester, six hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and

heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Elementary Lessons in Electricity and Magnetism, by Jackson, is used as a text book.

Sophomore, second semester, four hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc.

It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, support for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application of mining machinery is found in the catalogues furnished by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte. Merriman's Mechanics of Materials is used as a text book.

Junior, first semester, five hours per week.

Junior, second semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the West. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's Treatise on Hydraulics is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power house are also made a part of this course. The text book used is *Steam Engines and Boilers*, by Kinealy.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr.

Senior, first semester, first term, five hours per week.

Senior, first semester, second term, three hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmissions, power transmission by continuous current, some properties of alternating currents, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the Junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due

to a locomotive, also stresses due to the wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. Steel Mill Buildings, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Junior, first semester, second term, six hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; construction of retaining walls, foundations, dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum's Steel Mill Buildings.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN.

PROFESSOR CRAVEN, ASSISTANT PROFESSOR ADAMI

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The student should consult the instructor in charge in regard to the kind and number of instruments necessary.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshmen, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subject laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering

drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, head frames and machine drills with the conventions used in mine and geological maps, and many other useful items used in mining.

Freshman, second semester, six hours per week.

Descriptive Geometry.—Two hours per week throughout the Freshman year are occupied with recitations in descriptive geometry. Throughout the course the students study assigned lessons from a text book, together with the notation work, etc. The class period is taken up for the most part with the working of new problems, especially those involving the point, line, and plane; it is a drill hour in rapidity and accuracy in the application of the essential features of the subject. The procedure insures a thorough mastery of all the elements, an acquisition which is of great value in much of the work of the mining engineer. It assists him in his mechanical drawing and designing, it is indispensable in many problems in mine surveying and aids greatly in part of the work in geology especially in the practical work in mines where faults and veins are traced and platted.

In the latter part of the work where the more complicated intersections of solids and the developments of surfaces are required, the class works in the drawing room. Here the problems are likewise varied so that the possibility of merely copying or committing to memory is eliminated. The course follows in close touch with the regular mechanical drawing where the more elaborate drawings are completed, dimensioned and inked. The text used is Faunce's Descriptive Geometry.

Freshman year, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Plane Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of bearings, co-ordinates, elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requires a thorough knowledge of algebra, geometry, and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Mine Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating qualities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Plane Surveying, Field Work.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Freshman Summer Course, four weeks.

Mine Surveying, Field Work.—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc; Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shift by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the coordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above

an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods.

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the Sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, first term, nine hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines where mining operations are observed.

Junior, first and second semester, two hours per week.

Mining Laboratory Practice.—One afternoon a week is spent in studying air drills, besides making actual tests on various kinds of drills, such as air consumption, rate of drilling, efficiency tests and cost of operating. In addition to the above the students take trips underground to make a study of the practical side of mining. Special attention is given to the uses and handling of explosives, methods of timbering, stoping, diamond drilling and boring by percussion drills.

Juniors, second semester, second term, one afternoon per week.

Mining.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Air compression. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, first semester, first term, two hours per week.

Senior, first semester, second term, three hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principal types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, two hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Study of the construction and operation of typical milling machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, two hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in wood, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general

offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, first semester, second term, nine hours per week.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures, this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

MINING LAW.

JUDGE EDWARD B. HOWELL OF THE MONTANA BAR.

A course of instruction on the law relating to mining claims, including the method of acquiring title from the United States to lode, placer, tunnel and mill-site claims in the various states and Alaska, with a comparative study of federal and state laws on the subject, the law relating to extralateral rights, leases, options to purchase, conveyance of mining claims, and water rights, the relative rights of citizens and aliens in the tenure of mining claims. The object of the course is to give the student a good working knowledge of mining law, and to this end students are required to draft location notices and similar instruments that might become necessary in their work in the field. Through the recitations the class is given a thorough drill in rights of the locator also in ways in which these rights may be transmitted or may be forfeited, all principles being abundantly illustrated by actual and hypothetical cases. Questions of more complexity are illustrated by elaborate models and charts, many of these models were constructed to represent the claims of mining companies in the courts.

The course in Mining Law consists of lectures and recitations covering a period of two months and is required of the Senior class. The class uses as a text book for this course Mr. Howell's manual on "Lode and Placer Claims."

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the School. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. The department is furnished with large recitation and lecture rooms on the first floor, abundantly supplied with blackboard space, terrestrial and celestial globes, some simple models, and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qual-

itative and quantitative analysis, one for metallurgy, and two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of the student in the laboratories. These balances are placed on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the student in the laboratories and all check analysis on the students' work is made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast

and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces and one gasoline furnace, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a Brown planetary pulverizer, a buckingboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold and silver ores, together with mattes, both copper and lead, slag, flue-dust, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for the hyposulphite treatment. There are arrangements for treating free milling gold

ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

MINING, ORE DRESSING, AND METALLURGY.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing-boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following instruments have been provided: Ten engineering transits; one from Buff and Buff, two from C. L. Berger & Sons,

four from Gurley, one from Keuffel and Esser, one from Young & Son, and one from Eugene Dietzgen. Five levels—one from Buff, one from Gurley, two from Keuffel & Esser, one from Berger, and one from Young & son. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short and Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plumbets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four-foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

An equipment for making cyaniding tests provides for leaching ores in five-ton lots. In this plant sands and slimes may be separated, dewatered and treated separately. There are five vats and two sump tanks, one steel tank provided with air and mechanical agitators. All necessary filters, zinc boxes, etc., for making commercial tests are installed for use in this plant.

A pan amalgamation plant consists of a Bruckner chloridizing furnace, a pan amalgamator and settling tank. All the usual equipment, such as steam, launders and utensils, etc., are at hand for the convenient working of this plant.

The laboratory contains a Wedge furnace designed to be used as a reverberatory or a muffler furnace. This furnace is mechanically rabbled and used in roasting ores in lots of one ton or more. There is also a lead-line agitation barrel provided for experiments involving this type of apparatus.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs. Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its

travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Boston & Montana concentrator at Great Falls, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mine and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of the coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and

methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies five rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the museums, the petrographic laboratory, dark room and storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of the rarer, larger and more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geological and areal maps. The dark room on the third floor contains apparatus and chemicals

for photographic work. The storage room on the same floor contains materials for exchange, etc.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallagraphy but also as material for laboratory exercises. In addition to these real crystals, four series of crystal models are available, two of wood, one of celluloid and one of glass. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Twenty-four large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, specimens illustrating geologic structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to the Dana classification. A collection of one hundred and sixty gold crystals is kept in one of the cases. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collections contain over fifteen hundred. The museum in all contains over ten thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology.

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommo-

dating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers, Westphal balances, Plattner scales, burettes and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here also will be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks.

The working paleontological collection consists of over two thousand catalogued fossils, systematically arranged in cases in the Museum.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels, aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nachet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and the two of them, one Leitz and one Nachet, are of a larger size than the others, and are equipped with accessories for research work. The School owns a fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the

museum contains five hundred slides of minerals, six hundred thin sections of rocks, and one hundred slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are nearly all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with his microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals, and for polishing opaque minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a diamond wheel for cutting slides, and with two emery wheels for grinding. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating

the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

An engine and dynamo laboratory is located in the basement of the building; there is installed here a gas engine of ten horsepower for experimental purposes. A ten horsepower three phase induction motor drives direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. It is charged from the direct current dynamo or mercury arc rectifier. The requisite voltmeters and ammeters for both alternating and direct currents, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

The power plant for the mill contains two 80 horsepower boilers, a 75 horsepower high speed engine belted to a 50 K. W., three-phase generator with switchboard and necessary instruments, and an air compressor with

steam cylinders 8-inch by 10-inch and air cylinders 7½-inch and 13-inch by 10-inch.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression, and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subject to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks, Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building, its windows facing the main range of the Rocky Mountains and overlooking the famous Anaconda Hill. It is a large, well-lighted room and offers with its alcoves a convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others is nearly 9,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; Engineering Corps, and Bureau of Mines. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, geological and literary magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnished in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers, and periodicals issues of other colleges.

LIST OF STUDENTS.

SENIOR CLASS.

Cole, Robert J.....	Seattle, Washington
Lyden, Joseph P.....	Butte, Montana
McMahon, Brandon.....	Butte, Montana
MacPherson, Frank H.....	Butte, Montana
Murphy, Joseph G.....	Seattle, Washington
Ternouth, Blaine.....	Butte, Montana

JUNIOR CLASS.

Aline, Peter A.....	Great Falls, Montana
Amidon, Richard G.....	Minneapolis, Minnesota
Hunt, John E.....	Butte, Montana
Reber, Bert A.....	Butte, Montana
Sheedy, John W.....	Missoula, Montana
Watson, Robert I.....	Park City, Utah
Woodworth, Guy.....	Great Falls, Montana

SOPHOMORE CLASS.

Curran, Francis R.....	Butte, Montana
Gaethke, Fred P.....	Butte, Montana
Hill, William J.....	South Bend, Indiana
Hogan, Eugene.....	Butte, Montana
Kizer, Lloyd T.....	South Bend, Indiana
Lind, A. Leslie.....	Butte, Montana
Lyon, T. T., Jr.....	Butte, Montana
Mason, Veyne V.....	Helena, Montana
Simons, Walter W.....	Butte, Montana
Steele, Chester.....	Butte, Montana
Strang, Willis B.....	Musselshell, Montana

FRESHMAN CLASS.

Barry, John.....	Butte, Montana
Bennetts, John C.....	Butte, Montana
Bloom, Samuel S.....	Butte, Montana
Brasier, Charles A.....	Butte, Montana
Cannon, Frank D.....	Gibbonsville, Idaho
Carlisle, Stanley B.....	Winfield, Kansas
Cheung, T. C.....	Hong Kong, China

Collins, Thomas F.....	Butte, Montana
Driscoll, Thomas.....	Butte, Montana
Emigh, Hewitt B.....	Salmon, Idaho
Freshman, Herman.....	Butte, Montana
Gabisch, Francis.....	Helena, Montana
Hale, Emmet.....	Butte, Montana
Lee, L. P.....	Hong Kong, China
Lowney, James.....	Butte, Montana
Lyford, Earl R.....	Butte, Montana
McDougall, Allan.....	Butte, Montana
Norton, John E.....	Butte, Montana
Oyler, Coleman H.....	Butte, Montana
Parker, Howard.....	Butte, Montana
Sparks, Karl.....	Butte, Montana
Spiegel, Sam.....	Butte, Montana
Vivian, George.....	Butte, Montana
Wilkinson, Thomas.....	Butte, Montana

SPECIAL STUDENTS.

Blake, C. S.....	Silver Bow, Montana
Loughran, Dave.....	Butte, Montana
MacDonald, William.....	Butte, Montana
Naughton, Alice M.....	Butte, Montana
Neelon, Francis A.....	Minneapolis, Minnesota
Papa, J. M. A.....	Butte, Montana
Paquette, E. A.....	Butte, Montana
Sudzum, Marco.....	Butte, Montana

REGISTER OF ALUMNI.

CLASS OF 1903.

Bender, Louis V.....Anaconda, Montana
Asst. General Superintendent Washoe Reduction Works.

CLASS OF 1904.

Balmforth, Alfred.....Organ, New Mexico
Vice-President and General Manager San Andreas Mining Co.

Duling, J. Fred.....Los Angeles, California
Mining and Civil Engineer, Washington Building.

Ireland, Arthur J.....Helena, Montana
Mining Engineer.

Kuphal, Henry E.....San Pedro, California
Asst. Engineer Rancho Paloverdi.

MacRae, Lachlan D.....Nacozari, Sonora, Mexico
Construction Engineer, Nacozari Railway.

McGee, John.....Dale, via Amboy, California
General Manager United Greenwater Copper Co.

Pauly, P. L.....Butte, Montana
Draftsman, Butte & Duluth Mining Co.

Reese, Clara Clark.....Butte, Montana

Stevenson, Isabel Little.....Newburg, West Virginia

Tallant, Harry S.....Palma Sola, Florida
Farming.

CLASS OF 1905.

Archibald, George B.....Salt Lake, Utah
Carey Act and Mineral Inspector, General Land Office, Department of the Interior.

Brinton, Owen F.....Butte, Montana
Shift Boss, Pennsylvania Mine, A. C. M. Co.

Corey, C. R.....Seattle, Washington
Asst. Professor of Metallurgy, College of Mines, University of Washington.

Duthie, John M.....Libbey, Montana
Mining and Civil Engineer.

Elford, Basil.....Tonopah, Nevada
Assayer, Tonopah Extension Mining Co.

Mackel, Louis C.....Whitehall, Montana

Pratt, Paul D.....Libby, Montana
Mining and Civil Engineer (Custom Work).

Stevenson, L. C.....Newburg, West Virginia
Supt. Virginia-Maryland Coal Corporation.

VanGundy, J. E.....Kellogg, Idaho
Mining Engineer, Stewart Mining Co.

CLASS OF 1906.

Dugan, J. F.....	Butte, Montana
<i>Engineer, Anaconda Copper Mining Co.</i>	
Feeney, Charles W.....	Butte, Montana
<i>County Surveyor, Silver Bow County.</i>	
Gieser, Herbert S.....	Cerro de Pasco, Peru
<i>Supt. Cyanide Experimental Plant, Cerro de Pasco Mining Co.</i>	
Johns, John W.....	Butte, Montana
<i>Timber Boss, Leonard Mine, A. C. M. Co.</i>	
Kane, L. M.....	Butte, Montana
<i>Deputy City Clerk and Recorder.</i>	
Warfield, Hershel.....	Chicago, Illinois
<i>Financing New Corporations, Bonds, Mortgages, Mining Enterprises.</i>	
Wilson, Bert T.....	
Young, Arthur B.....	Canille, Arizona
<i>Mining Engineer.</i>	
Young, S. A.....	Astoria, Oregon

CLASS OF 1907.

Adami, Arthur E.....	Butte, Montana
<i>Asst. Professor Mining Engineering, Mont. State School of Mines.</i>	
Bovett, C. A.....	Ludwig, Nevada
<i>Engineer of Mines and R. R., Nevada-Douglas Copper Co.</i>	
McCracken, R. H.....	Kellogg, Idaho
<i>Prospecting.</i>	
Reardon, D. J.....	Butte, Montana
<i>Deputy County Surveyor, Silver Bow County.</i>	
Schafer, W. A., died August 13th, 1913.....	Metcalf, Arizona

CLASS OF 1908.

Bowden, Malcolm.....	Hecla, Montana
<i>Engineer, Penobscot Mining Co.</i>	
Ellis, Willis H.....	Butte, Montana
<i>Transit Man, City of Butte.</i>	
Foote, Frank A.....	Sutherland, Utah
<i>Farmer.</i>	
Ketcham, S. H.....	Missoula, Montana
<i>Mining Engineer, private practice.</i>	
Lomas, E. P.....	Butte, Montana
<i>Engineer, Tramway Mine, A. C. M. Co.</i>	
Lowry, T. M.....	Butte, Montana
<i>Engineering Dept., Montana Power Co.</i>	
McLaughlin, William D.....	Butte, Montana
<i>Surveyor, Tramway Mine, A. C. M. Co.</i>	
Meiklejohn, Archie B.....	Los Angeles, California
O'Brien, Albert.....	Butte, Montana
<i>Mining Engineer, Barker & Wilson.</i>	
Patten, Earle B.....	Philipsburg, Montana
<i>Mining Engineer; County Surveyor, Granite County.</i>	

Proctor, I. O.....	Butte, Montana
<i>Metallurgical Engineer, Colusa Parrot M. & S. Co.</i>	
Proctor, M. D.....	Truly, Montana
<i>McNain & Proctor Ranch Co.</i>	
Schiffner, Otto E.....	Dale, via Amboy, California
<i>Engineer, United Greenwater Copper Co.</i>	
Villars, Jesse R.....	Great Falls, Montana
<i>Mining and Civil Engineer, private practice.</i>	
Walton, Lee M.....	Luning Nevada
<i>Engineer, Wagner Azurite Copper Co.</i>	
Wren, A. A.....	Kimberly, Nevada
<i>Mining Engineer, in charge Churn Drilling for Consolidated Copper Mines Co.</i>	

CLASS OF 1909.

Brulo, William.....	Helena, Montana
<i>Deputy State Land Agent for Montana.</i>	
Evans, James R.....	Stanleyville, Belgium Kongo, West Africa
<i>Formanier.</i>	
Gilham, Ralph	Townsend, Montana
Haines, Peter A.....	Rivermines, Missouri
<i>Asst. Superintendent Doe Run Lead Co.</i>	
Johnstone, J. Clark.....	Jerome, Arizona
<i>United Verde Copper Co., Smelter.</i>	
Kane, Edward G.....	Butte, Montana
<i>Mining Engineer, A. C. M. Co.</i>	
Kirby, Kenneth P.....	Butte, Montana
<i>Mining Engineer, A. C. M. Co.</i>	
Loughran, Michael.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
Malloy, Emmett E.....	Butte, Montana
<i>Shift Boss, Diamond Mine, A. C. M. Co.</i>	
Peters, Ira B.....	Butte, Montana
<i>Engineer, City Engineer's Office.</i>	
Stockett, Norman A.....	Gowganda, Ont., Canada
<i>Superintendent Willing Mining Co.</i>	
Wiegenstein, Henry J.....	Butte, Montana
<i>Shift Boss, Diamond Mine, A. C. M. Co.</i>	
Young, William A.....	Lewistown, Montana
<i>Mining Engineer.</i>	

CLASS OF 1910.

Grunert, August.....	Butte, Montana
<i>Chemical Department, A. C. M. Co.</i>	
Jensen, Walter H.....	Great Falls, Montana
<i>Mining Engineer.</i>	
Stuewe, William, Jr.....	Gold Hill, Oregon
<i>Superintendent Braden Mine.</i>	

CLASS OF 1911.

Clinch, R. S.....	Nacozari, Sonora, Mexico
<i>Leasing</i>	
McElvenny, L. T.....	Junin, Peru, S. A.
<i>Asst. Supt. Morococha Mining Co.</i>	
Murphy, James K.....	Anaconda, Montana
<i>Laboratory Washoe Smelter, A. C. M. Co.</i>	
O'Connor, C. H.....	Butte, Montana
<i>Sampler, Speculator Mine, A. C. M. Co.</i>	
Peterson, P. E.....	Butte, Montana
<i>General Manager Butte Minnesota Mining Co.</i>	
<i>Peterson & Cohan, Engineers.</i>	
Roach, James, died June 2nd, 1912.....	
Shields, E. Floyd.....	Butte, Montana
<i>Mining Engineer, Butte & Superior Copper Co., Ltd.</i>	
Sultzzer, H. D.....	Cardwell, Montana
<i>Engineer and Mine Foreman Montana Illinois Copper Mining Co.</i>	
Tout, Charles.....	Butte, Montana
<i>Assayer, Tout & McCarthy.</i>	
Zentner, Arthur A.....	Anaconda, Montana
<i>Chemist with A. C. M. Co., Washoe Smelter.</i>	

CLASS OF 1912.

Andrew, John T.....	Notre Dame, Indiana
<i>Mining Law Student, Notre Dame University.</i>	
Bassett, Arthur F.....	Humboldt, Arizona
<i>Foreman of Flotation, Consolidated Arizona Smelting Co.</i>	
Christian, Otto B.....	Butte, Montana
<i>Draftsman, A. C. M. Co.</i>	
Clinch, Walter D.....	Butte, Montana
<i>Sampler, Moonlight Mine, A. C. M. Co.</i>	
Cohan, Jesse E.....	Butte, Montana
<i>Peterson & Cohan, Mining and Metallurgical Engineers.</i>	
Cooke, Hamilton, Jr.....	St. Louis, Missouri
Cullity, Emmet R.....	Berkeley, California
<i>Engineer, Structural and Estimating Dept., Panama Pacific International Exposition Co.</i>	
Fowler, George M.....	Maxville, Montana
<i>Mining Engineer, Royal Basin Mining Co.</i>	
Gidel, Murl H.....	Butte, Montana
<i>Asst. Geologist, A. C. M. Co.</i>	
Giovanetti, Ettore.....	Butte, Montana
<i>Instructor, Butte Business College.</i>	
Grupe, Charles.....	Aurora, Nevada
Pilger, Theo F.....	Butte, Montana
<i>Real Estate and Mines.</i>	
Williams, Paul K.....	Butte, Montana
<i>Sampler, North Butte Mining Co.</i>	

CLASS OF 1913.

Crittenden, Zar T.....	Butte, Montana
<i>Shift Boss, Butte Ballaklava Copper Co.</i>	
Dobson, Chris G.....	Butte, Montana
<i>Asst. Engineer, Original and Gagnon Mines, A. C. M. Co.</i>	
Hanson, Wilbur W.....	Butte, Montana
<i>Engineering Dept., A. C. M. Co.</i>	
McCool, Edward J.....	Butte, Montana
<i>Sampler, Silver Bow Mine, A. C. M. Co.</i>	
Manwaring, Joe H.....	Butte, Montana
<i>Mining Engineer, Butte Ballaklava Mining Co.</i>	
Newton, Lucian.....	Butte, Montana
<i>Shift Boss Butte Ballaklava Mining Co.</i>	
Pierse, Edwin A.....	Great Falls, Montana
<i>Consulting Engineer, Fergus, Regal and Little Rockies Gold Mining Co.</i>	
Pratt, A. F.	Portland, Oregon
Reid, Milton A.....	Anaconda, Montana
<i>Testing Laboratory, Washoe Smelter, A. C. M. Co.</i>	

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MONTANA STATE SCHOOL OF MINES

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OF THE
UNIVERSITY OF ILLINOIS

BUTTE, MONTANA

1915-16

MAR 1915

MONTANA STATE
SCHOOL OF MINES
BUTTE, MONTANA

THIRTEENTH ANNUAL CATALOGUE
OF OFFICERS AND STUDENTS
FOR THE YEAR
1914-1915

WITH ANNOUNCEMENTS FOR THE YEAR
1915-1916

SCHOOL CALENDAR 1915-16.

1915

September 7, First Semester begins.
November 12, Close of First Term.
November 15, Second Term, First Semester begins.
November 25-26, Thanksgiving Recess.
December 23, Holiday Recess begins.

1916

January 3, Holiday Recess ends.
January 21, End of First Semester.
January 24, Second Semester begins.
March 31, End of First Term Second Semester.
April 3, Second Term, Second Semester begins.
June 2, Commencement Day.
September 5, First Semester begins.

1915.	1916.	1917.
JULY	JANUARY	JANUARY
S M T W T F S	S M T W T F S	S M T W T F S
4 5 6 7 8 9 10	2 3 4 5 6 7 8	1 2 3 4 5 6
11 12 13 14 15 16 17	9 10 11 12 13 14 15	7 8 9 10 11 12 13
18 19 20 21 22 23 24	16 17 18 19 20 21 22	14 15 16 17 18 19 20
25 26 27 28 29 30 31	23 24 25 26 27 28 29	21 22 23 24 25 26 27
	30 31	28 29 30 31
AUGUST	FEBRUARY	FEBRUARY
S M T W T F S	S M T W T F S	S M T W T F S
1 2 3 4 5 6 7	1 2 3 4 5	1 2 3
8 9 10 11 12 13 14	6 7 8 9 10 11 12	4 5 6 7 8 9 10
15 16 17 18 19 20 21	13 14 15 16 17 18 19	11 12 13 14 15 16 17
22 23 24 25 26 27 28	20 21 22 23 24 25 26	18 19 20 21 22 23 24
29 30 31	27 28 29	25 26 27 28
SEPTEMBER	MARCH	MARCH
S M T W T F S	S M T W T F S	S M T W T F S
5 6 7 8 9 10 11	5 6 7 8 9 10 11	4 5 6 7 8 9 10
12 13 14 15 16 17 18	12 13 14 15 16 17 18	11 12 13 14 15 16 17
19 20 21 22 23 24 25	19 20 21 22 23 24 25	18 19 20 21 22 23 24
26 27 28 29 30	26 27 28 29 30 31	25 26 27 28 29 30 31
OCTOBER	APRIL	APRIL
S M T W T F S	S M T W T F S	S M T W T F S
3 4 5 6 7 8 9	2 3 4 5 6 7 8	1 2 3 4 5 6 7
10 11 12 13 14 15 16	9 10 11 12 13 14 15	8 9 10 11 12 13 14
17 18 19 20 21 22 23	16 17 18 19 20 21 22	15 16 17 18 19 20 21
24 25 26 27 28 29 30	23 24 25 26 27 28 29	22 23 24 25 26 27 28
31	30	29 30
NOVEMBER	MAY	MAY
S M T W T F S	S M T W T F S	S M T W T F S
7 8 9 10 11 12 13	1 2 3 4 5 6	1 2 3 4 5
14 15 16 17 18 19 20	7 8 9 10 11 12 13	6 7 8 9 10 11 12
21 22 23 24 25 26 27	14 15 16 17 18 19 20	13 14 15 16 17 18 19
28 29 30	21 22 23 24 25 26 27	20 21 22 23 24 25 26
	28 29 30 31	27 28 29 30 31
DECEMBER	JUNE	JUNE
S M T W T F S	S M T W T F S	S M T W T F S
5 6 7 8 9 10 11	4 5 6 7 8 9 10	3 4 5 6 7 8 9
12 13 14 15 16 17 18	11 12 13 14 15 16 17	10 11 12 13 14 15 16
19 20 21 22 23 24 25	18 19 20 21 22 23 24	17 18 19 20 21 22 23
26 27 28 29 30 31	25 26 27 28 29 30	24 25 26 27 28 29 30
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BOARDS OF CONTROL.

STATE BOARD OF EDUCATION.

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President of the Board.

H. A. DAVEE, Superintendent of Public Instruction,

Secretary of the Board.

D. M. KELLY, Attorney General,

S. D. LARGENT

W. S. HARTMAN

JOHN DIETRICH

J. C. SMITH

C. H. HALL

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Professor of Mining Engineering.

D. C. BARD, A. B.,
Professor of Geology and Mineralogy.

LESTER J. HARTZELL, E. M.,
Professor of Chemistry.

BANCROFT GORE, A. B.,
Professor of Metallurgy.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.
Assistant Professor of Mining Engineering.

CHARLOTTE RUSSELL,
Librarian and Registrar.

M. F. HALEY,
Assistant Millman.

MONTANA STATE SCHOOL OF MINES.

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It is a significant date, as it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agricultural and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located in Butte just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public-spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the grounds overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given this locality such publicity that no one now needs to be told of its leading position in the mining world.

The great reduction plants that have hertofore handled the ore that comes from the mines of this city are being enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the extensive mining and metallurgical plants in the vicinity of the School.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter, the opportunity is here presented for daily observation of work,

the development and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the School under the guidance of instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the School. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The fourth floor is given up mainly to museums containing extensive collections of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with requisite cabinets of rock specimens, thin sections, etc.; the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now in practice, a detailed account of which may be found under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the

school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gynasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may also be used as a general auditorium on special occasions. Connected with the gymnasium are two parlors, a dressing room, and in the basement a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1917, is \$70,000.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The School is therefore wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two

laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for the work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which they come.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory

evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

ACCREDITED HIGH SCHOOLS OF MONTANA.

All the County High Schools are accredited. The following District High Schools are also accredited:

Anaconda	Forsyth	Moore
Belt	Glasgow	Plains
Billings	Great Falls	Polson
Butte	Hamilton	Pony
Chinook	Harlowtown	Stevensville
Columbus	Havre	Terry
Conrad	Helena	Victor
Eureka	Laurel	Virginia City
	Libby	Whitehall

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order, and the balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR.

General Chemistry and Qualitative Analysis	\$15.00
Surveying	10.00

SOPHOMORE YEAR.

Quantitative Analysis	\$15.00
Mineralogy	5.00
Deposit for Platinum Ware.....	30.00

JUNIOR YEAR.

Mining Surveying	\$10.00
Assaying	10.00

SENIOR YEAR.

Metallurgy	\$15.00
Petrography	10.00

When the breakage exceeds the deposits the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the School. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. Cost of text-books average about \$25.00 a year. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY.

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	6	6
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	9	9

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Analytical Geometry	5	5
Plane Surveying, Theory.....	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	9	9
Mechanical Drawing	6	6

Plane Surveying, Field Work, Summer Course of Four Weeks

SOPHOMORE YEAR

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Chemistry Laboratory	6	9
Mineralogy, Lectures	2	2
Mineralogy, Laboratory	0	6
Topographical Drawing	9	0

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Calculus, Anal. Mechanics....	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory.....	2	2
Mineralogy, Lectures	3	0
Geology, Lectures	0	3
Mining, Laboratory	0	3

JUNIOR YEAR

FIRST SEMESTER.

	First Term.		Second Term.
	Hours per Week.		Hours per Week.
Mechanics	5	.....	5
Mining	2	.....	2
Geology	5	.....	5
Metallurgy, Lectures	3	.....	3
Mine Surveying, Practice.....	15	.....	0
Engineering Design	0	.....	9
Graphics	0	.....	6

SECOND SEMESTER.

	First Term.		Second Term.
	Hours per Week.		Hours per Week.
Mechanics and Hydraulics....	5	.....	5
Mining	2	.....	2
Geology, Lectures	5	.....	5
Metallurgy, Lectures	3	.....	3
Engineering Design	6	.....	3
Geology, Field Work	3	.....	3
Assaying	6	.....	6
Mining, Laboratory	0	.....	3

SENIOR YEAR.

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Geology	5	5
Mining	2	3
Ore Dressing	0	2
Metallurgy	3	2
Mechanical Engineering	5	3
Geology, Field Work.....	0	3
Metallurgical Laboratory	15	6
Engineering Design	0	6

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Mining	3	3
Ore Dressing	2	2
Metallurgy	3	3
Metallurgy, Laboratory	6	6
Power Transmission	3	3
Engineering Construction	2	2
Engineering Design	6	6
Petrography	5	5
Mining Law	2	0

ENGLISH.

Two hours per week during the Freshman year are allotted to the study of English composition. The work is designed to continue the training outlined in the usual high school course, the chief aim being to create an individual and effective means of expression and communication for the ordinary demands of professional life. The ability to express oneself accurately and with some degree of elegance is an advantage which is not easily overestimated. At the same time the stimulating of literary sympathy and appreciation is kept in view, this we deem especially desirable in a professional course, as it supplies an element which is a source of pleasure in after life.

The work begins with a series of classroom lectures and discussions during which time the students are given simple exercises in writing; special attention is given to grammar, punctuation, choice of words, etc. Finally this work is extended to the study of the paragraph and the more complete theme.

During the latter part of the year the class is organized to develop the debate together with the regular theme writing. Proper form and fluency in speaking to an audience is a matter cultivated throughout the year. Among the other helpful features of the course may be mentioned a thorough and practical drill in parliamentary law, instruction on note taking, on making outlines, on writing examination papers and on the use of the library. The reading assignments for critical study are drawn mainly from the best technical magazines, from the best editorials, while occasionally a book of purely literary merit is assigned for review.

MATHEMATICS.

PROFESSORS CRAVEN AND BOWMAN, ASST. PROFESSOR ADAMI.

Algebra.—A preliminary course is first given designed to drill the student in the fundamental algebraic operations and in the statement and solution of simple mechanical problems. This review is followed for the remainder of the semester by a careful study of those operations of advanced algebra which will be of use to the student in future engineering courses. Special attention is given to the theory and use of exponents and logarithms, simultaneous quadratic equations, the more common series with their practical applications, indeterminate coefficients and quantics solved by synthetic division and by graphical methods. Text, Wentworth's College Algebra.

Freshman first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and

oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's Plane and Spherical Trigonometry.

Freshman, first semester, five hours per week.

Analytical Geometry.—This course from its very nature becomes a thorough review of algebra, geometry, and trigonometry. The material gathered from these three sources is combined in a most striking way which leads to a more practical working knowledge of these branches of mathematics. The student is required to study and plot accurately numerous problems covering such topics as, the point and straight line in a plane, different systems of co-ordinates, conic sections, higher plane curves, the point and straight line in space, curved surfaces, and surfaces of revolution. Toward the end of the course the student is required to study various mechanical movements, to devise movements and to determine the laws and equations involved. Text, Wentworth's Analytical Geometry.

Freshman, second semester, five hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maxima and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia, and work. The text used is Taylor's Differential and Integral Calculus.

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY.

PROFESSOR BARD.

The geologic side of engineering is presented to the student through courses in Mineralogy, Geology and Petrography.

Mineralogy.—Text book is Rogers' "Study of Minerals." The purpose of this course is to familiarize the student with about two hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blowpipe Analysis, and by comparison with known mineral specimens. Thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarize the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other tests of importance in mineralogy. The optical properties of mineral fragments are studied with petrographic microscopes.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. The introductory lectures take up the character of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.
Sophomores, first semester, second term, eight hours per week.
Sophomores, second semester, first term, nine hours per week.
Sophomores, second semester, second term, six hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Chamberlain and Salisbury's "College Geology."

Sophomores, second semester, second term, three hours per week.
Juniors, first semester, five hours per week.
Juniors, second semester, first term, eight hours per week.

Economic Geology.—This course takes up the principles of mineral disposition, both metallic and non-metallic, geologic relations, commercial value and geographic distribution of the more important mineral districts are considered. Field

trips are made to mines and quarries to supplement the lecture work. The textbook used is Lindgren's "Mineral Deposits," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.

Seniors, first semester, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—A course in microscopical petrography is provided for the senior year. The principles and objects of the use of the microscope are outlined in an earlier course. Winchell's "Elements of Optical Mineralogy" is used for reference. The student is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Seniors, second semester, five hours per week.

CHEMISTRY

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principals of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to another, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from text-book references, and it is essential for those who take the course to take notes on the lectures which are designed to aid and direct the work performed in laboratory practice during the semester. The text book used is "Principles of Chemistry" by Kahlenberg.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

*Freshmen, first semester, six hours per week.
Freshmen, second semester, nine hours per week.*

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

Freshmen, second semester, three hours per week.

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such, as analysis of limestone, dolomites, rock analysis, ores of iron, magnese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, flue dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and laboratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these practical features are employed the instructor bears it ever in mind that through all the work the student must be required to use his own talents and learn to think and reason for himself.

Sophomores, first semester, first term, two hours lecture per week and six hours laboratory.

Sophomores, first semester, second term, one hour lecture per week and nine hours laboratory.

Sophomores, second semester, one hour lecture per week and nine hours laboratory.

METALLURGY.

PROFESSOR CORE, MR. HALEY.

Introduction to Metallurgy.—The study of Metallurgy begins with lectures and recitations on the fundamental principles of the science. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, products of combustion, etc., are studied. The various fuel, solid, liquid and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast reverberatory, muffled and electric, used in metallurgical operations are described. In connection with this the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation rooms, one week is devoted to a practical study of the smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations observed is required of each student. The text book used is Peter's Practice of Copper Smelting.

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver.—The second semester of the junior year is devoted to the metallurgy of gold and silver. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The

other metallurgical processes for silver, such as the Washoe process and the hyposulphite lixiviation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants of Deadwood, South Dakota, or other places, where a careful study is made of the process and a detailed typewritten report is made by each student. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Silver.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments, submitting a written report of the examinations made at the works.

Senior, first semester, first term, three hours per week.

Senior, first semester, second term, two hours per week.

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through reference to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

Fire Assaying.—The course in fire assaying is essentially a laboratory drill course. It comes during the Junior and Senior years when the students are familiar with the reagents and most of the chemical reactions used in the work. However, the laboratory work is preceded by a short course in lectures in which the general principles of the art are developed and all equipment carefully explained. Attention is given to the proper care of the furnace and method of controlling the temperature. The special balances used in this work are demonstrated, showing methods of operating, care and adjustments. Finally the class is given a series of notes which embody a description of the charges in actual use in the mining and smelting plants of the West.

In the laboratory work each student is given a desk with a full equipment of reagents and apparatus. Ample furnace room, balances and ore-grinding apparatus are provided so no delays are encountered through lack of equipment. Then each student works through his individual list of ores to be assayed. There are silicious oxidized ores, basic oxidized ores, ores of lead, copper and zinc; all containing various impurities. These are assayed for gold and silver and when lead is present it is also determined. The smelter products likewise receive attention; lead and copper mattes, speiss, antimonial lead, lead and copper bullion, lead and copper slags are all treated according to the custom about the laboratory of the smelter.

Both crucible and scorification methods are used where considered practicable, while the combined wet and dry methods are used upon material such as copper bullion, mattes high in copper, blister copper, etc.

The laboratory work covers about twenty weeks of two afternoons each week. Throughout the course speed and accuracy are considered essential points. Before a student is considered proficient he must be able to accomplish what may be considered a reasonable day's work in a commercial laboratory. Accuracy is required, but it is not sufficient, the speed is considered equally important.

In this course no charge is made for materials or equipment except where there is an unnecessary breakage or consumption of material.

Junior, second semester, two afternoons per week.

Metallurgical Laboratory Practice.—The work of the first term of the Senior year includes the systematic investigation of a large variety of commercial ores for the purpose of determining in each case the most economical metallurgical process for the recovery of the precious or base metals. In connection with this work the students have access to special laboratory equipment of the most approved type for ore testing on a miniature scale. Recent additions to this laboratory include a slide-testing machine for the study on a reduced scale of the oil-flotation process; a large porcelain

pebble mill for all-sliming operations, grinding in solution and chlorination work; special air agitation apparatus for the cyanide treatment of refractory ores and concentrates; individual vacuum filters and a small Kelly filter press for the study of problems involving slime filtration and washing.

A small lot of uncrushed ore, generally not less than fifty pounds, is given to each student, who first makes a careful physical examination indicating the minerals containing the precious or base metals, those composing the gangue, nature of the ore and such characteristics as might have a bearing on the particular line of investigation to be followed. An accurate sample is then prepared, assayed and analyzed for the usual constituents determined in metallurgical practice. A scheme of treatment is then outlined and the results obtained are systematically tabulated, forming the basis of an individual report on the economical treatment of the ore in question.

Experience gained in previous years' work in mineralogy assaying and metallurgical analysis is made frequent use of in this course and accordingly no student will be admitted unless qualified in these subjects.

Special emphasis will be given to processes of current interest open to important future developments such as the recovery of values from refractory gold and silver ores and concentrates, oil flotation methods and hydrometallurgical treatment of copper ores. There is practice work in amalgamation, concentration, chloridizing roasting, hyposulphite leaching, magnetic separation and dry chlorination.

Senior, first semester, first term, five afternoons per week.

Metallurgical Mill Practice.—Data obtained in the metallurgical laboratory during the first semester forms the basis of actual mill tests during the balance of the school year, the aim being to duplicate on a commercial scale the results previously obtained from laboratory samples.

For this work there are crushers, rolls, mills, etc., so arranged as to reduce the handling of the ore to a minimum.

A battery of three stamps offers practice in stamp milling during which tests the class is given practice in dressing the plates and recovering the bullion. Other tests involve the use of amalgamating pans, cyanide vats of three tons capacity, a slime and agitation equipment, a lead lined agitation barrel for chlorination work. There are also roasting furnaces with which any of the roasting operations may be carried out that are required in the standard processes of ore treatment.

During this work much attention is given to the handling and adjusting of machinery. Under proper instruction the students operate the mill from the power plant to the tailings dump. This experience is a valuable asset to any young engineer undertaking work, especially with the smaller plants of the west, since mining engineers, even if they are not

metallurgists, are frequently called on to operate ore dressing or milling plants. The course also gives excellent opportunity for gaining experience in methods of sampling.

One hour each week is devoted to a discussion of the principles involved in each of the milling operations and individual reports are read and commented upon.

*Seniors, first semester, second term, two afternoons per week.
Seniors, second semester, two afternoons per week, conferences one hour per week.*

MECHANICS

PROFESSORS CRAVEN AND BOWMAN.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text-book used is "Elements of Mechanics," by Merriman.

Sophomores, first semester, six hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and

heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. Elementary Lessons in Electricity and Magnetism, by Jackson, is used as a text book.

Sophomores, second semester, four hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc.

It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, support for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application of mining machinery is found in the catalogues furnished by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte. Merriman's *Mechanics of Materials* is used as a text book.

Junior, first semester, five hours per week.

Junior, second semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the West. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's *Treatise on Hydraulics* is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power house are also made a part of this course. The text book used is *Steam Engines and Boilers*, by Kinealy.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr.

Senior, first semester, second term, three hours per week.

Senior, first semester, first term, five hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power purposes in the west, have prompted us to give rather extended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmissions, power transmission by continuous current, some properties of alternating currents, power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is *Power Transmission*, by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the Junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chords, and continuous trusses. In these problems concentrated and uniform loads are considered stresses due

to a locomotive, also stresses due to the wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. Steel Mill Buildings, by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Junior, first semester, second term, six hours per week.

Engineering Construction.—This course consists of lectures and recitations, on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; construction of retaining walls, foundations, dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum's Steel Mill Buildings.

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN

PROFESSOR CRAVEN, ASSISTANT PROFESSOR ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The student should consult the instructor in charge in regard to the kind and number of instruments necessary.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. Mechanical Drawing, by Faunce, and Descriptive Geometry, by Faunce, are the text books used.

Freshmen, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subject laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering

drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, head frames and machine drills with the conventions used in mine and geological maps, and many other useful items used in mining.

Freshman, second semester, six hours per week.

Descriptive Geometry.—Two hours per week throughout the Freshman year are occupied with recitations in descriptive geometry. Throughout the course the students study assigned lessons from a text book, together with the notation work, etc. The class period is taken up for the most part with the working of new problems, especially those involving the point, line, and plane; it is a drill hour in rapidity and accuracy in the application of the essential features of the subject. The procedure insures a thorough mastery of all the elements, an acquisition which is of great value in much of the work of the mining engineer. It assists him in his mechanical drawing and designing, it is indispensable in many problems in mine surveying and aids greatly in part of the work in geology, especially in the practical work in mines where faults and veins are traced and platted.

In the latter part of the work where the more complicated intersections of solids and the developments of surfaces are required, the class works in the drawing room. Here the problems are likewise varied so that the possibility of merely copying or committing to memory is eliminated. The course follows in close touch with the regular mechanical drawing where the more elaborate drawings are completed, dimensioned and inked. The text used is Faunce's Descriptive Geometry.

Freshman year, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Plane Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of bearings, co-ordinates, elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requires a thorough knowledge of algebra, geometry and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Mine Surveying.—A course of lectures on underground surveying, location of roads, pipe lines, ditches and flumes for mining purposes; surveys for surface and aerial tramways; staking out buildings, structures, tracks, etc., required at a mine. The course in underground surveying also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating qualities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Plane Surveying, Field Work.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile, for contour lines and for establishment of bench marks. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Freshman Summer Course, four weeks.

Mine Surveying, Field Work.—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.: Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine, including shafts, levels, raises, winzes and stopes. Plumbing a vertical shaft by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the co-ordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the

vertical angles and slope distances. Checking surveys by platting and calculation, and adjusting allowable errors by approved methods.

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the Sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, first term, nine hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN.

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMI.

Mining.—An outline of the geographical and geological distribution of the ores of the useful metals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines where mining operations are observed.

Junior, first and second semester, two hours per week.

Mining Laboratory Practice.—One afternoon a week is spent in studying air drills, besides making actual tests on various kinds of drills, such as air consumption, rate of drilling, efficiency tests and cost of operating. In addition to the above the students take trips underground to make a study of the practical side of mining. Special attention is given to the uses and handling of explosives, methods of timbering, stopping, diamond drilling and boring by percussion drills.

Juniors, second semester, second term, one afternoon per week.

Mining.—Exploitation of the useful metals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Air compression. Ventilation, natural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

Senior, first semester, first term, two hours per week.

Senior, first semester, second term, three hours per week.

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicing and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principle types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, two hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindred settling. The principles of screen sizing and hydraulic classification. Study of the construction and operation of typical milling machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, two hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in woods, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general

offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, first semester, second term, nine hours per week.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

MINING LAW.

JUDGE EDWARD B. HOWELL OF THE MONTANA BAR.

A course of instruction on the law relating to mining claims, including the method of acquiring title from the United States to lode, placer, tunnel and mill-site claims in the various states and Alaska, with a comparative study of federal and state laws on the subject, the law relating to extralateral rights, leases, options to purchase, conveyance of mining claims, and water rights, the relative rights of citizens and aliens in the tenure of mining claims. The object of the course is to give the student a good working knowledge of mining law, and to this end students are required to draft location notices and similar instruments that might become necessary in their work in the field. Through the recitations the class is given a thorough drill in rights of the locator, also in ways in which these rights may be transmitted or may be forfeited, all principles being abundantly illustrated by actual and hypothetical cases. Questions of more complexity are illustrated by elaborate models and charts, many of these models were constructed to represent the claims of mining companies in the courts.

The course in Mining Law consists of lectures and recitations covering a period of two months and is required of the Senior class. The class uses as a text book for this course Mr. Howell's manual on "Lode and Placer Claims."

EQUIPMENT.

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the School. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. The department is furnished with large recitation and lecture rooms on the first floor, abundantly supplied with blackboard space, terrestrial and celestial globes, some simple models, and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qual-

itative and quantitative analysis, one for metallurgy, and two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of the student in the laboratories. These balances are placed on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the student in the laboratories and all check analysis on the students' work is made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast

and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

DEPARTMENT OF METALLURGY.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces and one gasoline furnace, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a Brown planetary pulverizer, a buckingboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold and silver ores, together with mattes, both copper and lead, slag, flue-dust, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for the hyposulphite treatment.

There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gases of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

MINING, ORE DRESSING, AND METALLURGY.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing-boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following instruments have been provided: Ten engineering transits:

one from Buff and Buff, two from C. L. Berger & Sons, four from Gurley, one from Keuffel and Esser, one from Young & Son, and one from Eugene Dietzgen. Five levels—one from Buff, one from Gurley, two from Keuffel & Esser, one from Berger, and one from Young & Son. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short & Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plumets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilflev table, one four-foot Erue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

An equipment for making cyaniding tests provides for leaching ores in five-ton lots. In this plant sands and slimes may be separated, dewatered and treated separately. There are five vats and two sump tanks, one steel tank provided with air and mechanical agitators. All necessary filters, zinc boxes, etc., for making commercial tests are installed for use in this plant.

A pan amalgamation plant consists of a Bruckner chloridizing furnace, a pan amalgamator and settling tank. All the usual equipment, such as steam, launders and utensils, etc., are at hand for the convenient working of this plant.

The laboratory contains a Wedge furnace designed to be used as a reverberatory or a muffler furnace. This furnace is mechanically rabbled and used in roasting ores in lots of one ton or more. There is also a lead-line agitation barrel provided for experiments involving this type of apparatus.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs, Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its

travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Boston & Montana concentrator at Great Falls, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Tavler & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and

methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies five rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the museums, the petrographic laboratory, dark room and storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of the rarer, larger and more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geological and areal maps. The dark room on the third floor contains apparatus and chemicals

for photographic work. The storage room on the same floor contains materials for exchange, etc.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercises. In addition to these real crystals, four series of crystal models are available, two of wood, one of celluloid and one of glass. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Twenty-four large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, specimens illustrating geologic structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to the Dana classification. A collection of one hundred and sixty gold crystals is kept in one of the cases. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collection contain over fifteen hundred specimens. The museum in all contains over ten thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology.

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommo-

dating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers, Westphal balances, Plattner scales, burettes and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here also will be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks. A Greenough-Leitz binocular microscope is available for the mineralogy laboratory.

The working paleontological collection consists of over two thousand catalogued fossils, systematically arranged in cases in the Museum.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels, aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nacet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and the two of them, one Leitz and one Nacet, are of a larger size than the others, and are equipped with accessories for research work. The School owns a fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the

museum contains five hundred slides of minerals, six hundred thin sections of rocks, and one hundred slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are nearly all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with his microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals, and for polishing opaque minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a diamond wheel for cutting slides, and with two emery wheels for grinding. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating

the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

An engine and dynamo laboratory is located in the basement of the building; there is installed here a gas engine of ten horsepower for experimental purposes. A ten horsepower three phase induction motor drives direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. It is charged from the direct current dynamo or mercury arc rectifier. The requisite voltmeters and ammeters for both alternating and direct currents, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

The power plant for the mill contains two 80 horsepower boilers, a 75 horsepower high speed engine belted to a 50 K. W., three-phase generator with switchboard and necessary instruments, and an air compressor with

steam cylinders 8-inch by 10-inch and air cylinders 7½-inch and 13-inch by 10-inch.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression, and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subject to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY.

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building, its windows facing the main range of the Rocky Mountains and overlooking the famous Anaconda Hill. It is a large, well-lighted room and offers with its alcoves a convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others is nearly 9,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; Engineering Corps, and Bureau of Mines. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, geological and literary magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnished in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers, and periodical issues of other colleges.

LIST OF STUDENTS.

SENIOR CLASS.

Aline, Peter A.....	Great Falls, Montana
Goodell, Luther T.....	Seattle, Washington
Hunt, John E.....	Butte, Montana
Reber, Bert A.....	Butte, Montana
Sheedy, John W.....	Missoula, Montana
Watson, Robert A.....	Park City, Utah
Woodworth, Guy T.....	Great Falls, Montana

JUNIOR CLASS.

Curran, Francis R.....	Butte, Montana
Gaethke, Fred P.....	Butte, Montana
Hill, William J.....	South Bend, Indiana
Hogan, Eugene.....	Butte, Montana
Lind, A. Leslie.....	Butte, Montana
Lyon, Thomas T., Jr.....	Butte, Montana
Mason, Veyne V.....	Helena, Montana
Neelon, Francis A.....	Minneapolis, Minnesota
Steele, Chester.....	Butte, Montana
Strang, Willis B.....	Mussellshell, Montana

SOPHOMORE CLASS.

Barry, John.....	Butte, Montana
Cannon, Frank D.....	Gibbonsville, Idaho
Carlisle, Stanley B.....	Winfield, Kansas
Cheung, T. C.....	Hong Kong, China
Collins, Thomas F.....	Butte, Montana
Driscoll, Thomas J.....	Butte, Montana
Emigh, Hewitt B.....	Salmon, Idaho
Freshman, Herman B.....	Butte, Montana
Gabisch, Francis.....	Helena, Montana
Lee, L. P.....	Hong Kong, China
Ling, Tao.....	Honan, China
Lyford, Earl R.....	Butte, Montana
Norton, John E.....	Butte, Montana
Papa, J. M. A.....	Butte, Montana
Parker, Howard.....	Butte, Montana
Petritz, William E.....	Rockford, Illinois
Sparks, Karl T.....	Butte, Montana
Spiegel, Sam.....	Butte, Montana

Vaupell, C. W.....	Lewistown, Montana
Vivian, George F.....	Butte, Montana
Wilkinson, Thomas	Butte, Montana

FRESHMAN CLASS.

Cliff, Frank M.....	Butte, Montana
Ellingwood, C. W., Jr.....	Butte, Montana
Hunt, Peter F.....	Butte, Montana
Loughran, Dave.....	Butte, Montana
McAuliffe, Charles, Jr.....	Butte, Montana
Makinson, Roy.....	Butte, Montana
Nelson, Alex S.....	Larson, Sweden
Newton, Claude.....	Butte, Montana
O'Donnell, Neil.....	Butte, Montana
Pierce, W. C.....	Arthur, Nevada
Thrasher, Willard.....	Butte, Montana

SPECIAL STUDENTS.

Cummins, Herschel M.....	Eagle, Idaho
Hoss, Fred M.....	Helena, Montana
Irvin, Roy Robert.....	Lawrence, Kansas
Martineau, C. F.....	Logan, Utah
Moses, P. S.....	Savannah, Georgia
Nuckolls, Friel S.....	Butte, Montana
Renger, Edward.....	Butte, Montana

REGISTER OF ALUMNI.

CLASS OF 1903.

Bender, Louis V.....Anaconda, Montana
General Superintendent Washoe Reduction Works.

CLASS OF 1904.

Balmforth, Alfred.....Organ, New Mexico
Vice-President and General Manager, San Andreas Mining Co.

Duling, J. Fred.....Los Angeles, California
Civil and Mining Engineering, Bennett & Duling.

Irelan, Arthur J.....Helena, Montana
Mining Engineer.

Kuphal, Henry E.....Missoula, Montana
Mining Engineer.

MacRae, Lachlan D.....San Antonio, Texas

McGee, John.....Dale, via Amboy, California
General Manager, United Greenwater Copper Co.

Pauly, P. L.....Butte, Montana
Draftsman, Butte & Duluth Mining Co.

Reese, Clara Clark.....Long Beach, California

Stevenson, Isabel Little.....Newburg, West Virginia

Tallant, Harry S.....Palma Sola, Florida
Farmer.

CLASS OF 1905.

Archibald, George B.....Salt Lake City, Utah
Carey Act and Mineral Inspector, General Land Office, Department of the Interior.

Brinton, Owen F.....
Namtun, Northern Shan States, Burma, India
Burma Mines Ltd.

Corey, C. R.....Seattle, Washington
Asst. Prof. of Metallurgy, College of Mines, University of Washington.

Duthie, John M.....Libby, Montana
Mining and Civil Engineering.

Elford, Basil E.....Anaconda, Montana
Testing Dep't., Washoe Smelter, A. C. M. Co.

Mackel, Louis C.....Whitehall, Montana
Farmer.

Pratt, Paul D.....Libby, Montana
Mining and Civil Engineering.

Stevenson, L. C.....Newburg, West Virginia
Superintendent, Virginia-Maryland Coal Corporation.

VanGundy, J. E.....Kellogg, Idaho
Mining Engineer, Stewart Mining Co.

CLASS OF 1906.

Dugan, J. F.....	Butte, Montana
<i>Asst. Foreman, Anaconda Mine, A. C. M. Co.</i>	
Feeney, Charles W.....	Butte, Montana
<i>County Surveyor, Silver Bow County.</i>	
Gieser, Herbert S.....	Cerro de Pasco, Peru
<i>Supt. Cyanide Experimental Plant, Cerro de Pasco Mining Co.</i>	
Johns, John W.....	Marysville, Montana
<i>Foreman Piegan-Gloster Mine, Barnes-King Mining Co.</i>	
Kane, L. M.....	Butte, Montana
<i>Mining.</i>	
Warfield, Hershel.....	Los Angeles, California
<i>With Campbell-Bentley Co., Brokers, Real Estate, Harbor Property.</i>	
Wilson, Bert T.....	Goldendale, Washington
<i>Goldendale Machine Shop and Garage.</i>	
<i>Consulting Engineer.</i>	
Young, Arthur B.....	Canille, Arizona
<i>Mining Engineer.</i>	
Young, S. A.....	Astoria, Oregon

CLASS OF 1907.

Adami, Arthur E.....	Butte, Montana
<i>Asst. Prof. Mining Engineering, Mont. State School of Mines.</i>	
Bovett, C. A.....	Ludwig, Nevada
<i>Engineer of Mines and R. R., Nevada-Douglas Copper Co.</i>	
McCracken, R. H.....	Philipsburg, Montana
<i>Prospecting.</i>	
Reardon, D. J.....	Butte, Montana
<i>Deputy County Surveyor, Silver Bow County.</i>	
Schafer, W. A., died August 13th, 1913.	

CLASS OF 1908.

Bowden, Malcolm.....	Helena, Montana
<i>Mining Engineer.</i>	
Ellis, Willis H.....	Butte, Montana
<i>Field Assistant to Commissioner of Public Works.</i>	
Foote, Frank A.....	Sutherland, Utah
<i>Farmer.</i>	
Ketcham, S. H.....	Missoula, Montana
<i>Private Practice, Civil and Mining Engineering.</i>	
Lomas, E. P.....	Butte, Montana
<i>Engineer, Tramway Mine, A. C. M. Co.</i>	
Lowry, T. M., Jr.....	Butte, Montana
<i>Engineer, Montana Power Company.</i>	
McLaughlin, William D.....	Butte, Montana
<i>Surveyor, Tramway Mine, A. C. M. Co.</i>	
Meiklejohn, Archie B.....	Los Angeles, California

O'Brien, Albert	Butte, Montana
<i>Draftsman Geological Dep't, A. C. M. Co.</i>	
Patten, Earle B.	Philipsburg, Montana
<i>Mining Engineer; County Surveyor, Granite Co.</i>	
Proctor, I. O.	Butte, Montana
<i>Flotation Dep't. Timber Butte Milling Co.</i>	
Proctor, M. D.	Truly, Montana
<i>McNain & Proctor Ranch Co.</i>	
Schiffner, Otto B.	Dale, via Amboy, California
<i>Engineer, United Greenwater Copper Co.</i>	
Villars, Jesse R.	Great Falls, Montana
<i>Civil and Mining Engineer, General Practice.</i>	
Walton, Lee M.	Maxville, Montana
<i>Engineer, Royal Basin Mining Co.</i>	
Wren, A. A.	McGill, Nevada
<i>Flotation of Copper Ores, Nevada Cons. Mining Co.</i>	

CLASS OF 1909.

Brulo, William	Helena, Montana
<i>Deputy State Land Agent for Montana.</i>	
Evans, James R.	Butte, Montana
<i>With Butte & Superior Mining Co.</i>	
Gilham, Ralph.	Townsend, Montana
Haines, Peter A.	Rivermines, Missouri
<i>Superintendent Doe Run Lead Co.</i>	
Johnstone, J. Clark.	Butte, Montana
<i>Examining Properties in California.</i>	
Kane, Edward G.	Butte, Montana
<i>Engineering Department, A. C. M. Co.</i>	
Kirby, Kenneth P.	Butte, Montana
<i>Engineering Department, A. C. M. Co.</i>	
Loughran, Michael.	Butte, Montana
<i>Engineering Department, A. C. M. Co.</i>	
Malloy, Emmett E.	Butte, Montana
<i>Deputy State Land Agent for Montana.</i>	
Peter, Ira B.	Butte, Montana
<i>Engineer, City Engineer's Office.</i>	
Stockett, Norman A.	Paragon, Coeur d'Alene Dist., Idaho
<i>Foreman, Paragon Con. Mining Co.</i>	
Wiegenstein, Henry J.	Butte, Montana
<i>Mining Engineer.</i>	
Young, William A.	Lewistown, Montana

CLASS OF 1910.

Grunert, August	Butte, Montana
<i>Assayer, A. C. M. Company.</i>	

- Jensen, Walter H.....Great Falls, Montana
Asst. Secretary Montana Brewing Co.
- Stuewe, William, Jr.....Gold Hill, Oregon
Superintendent Braden Mine.

CLASS OF 1911.

- Clinch, R. S.....Nacozari de Garcia, Sonora, Mexico
Ore Buyer.
- McElvenny, L. T.....Butte, Montana
Mining Engineer.
- Murphy, James K.....Anaconda, Montana
Supt. of the Roasting Plant Washoe Smelter, A. C. M. Co.
- O'Connor, C. H.....Anaconda, Montana
Testing Department, Washoe Smelter, A. C. M. Co.
- Peterson, P. E.....Maxville, Montana
Metallurgist, Royal Basin Mining and Milling Co.
- Roach, James, died June 2nd, 1912.
- Shields, E. Floyd.....Butte, Montana
Mining Engineer, Butte & Superior Mining Co., Ltd.
- Sultz, H. Duke.....Butte, Montana
Mining Engineer.
- Tout, Charles.....Sunset, Idaho
Operator, Magnetic Plant, Success Mine.
- Zentner, Arthur A.....Anaconda, Montana
Chemist, Washoe Smelter, A. C. M. Co.

CLASS OF 1912.

- Andrew, John T.....Butte, Montana
Law Student, Notre Dame University.
- Bassett, Arthur F.....Humboldt, Arizona
Asst. to Mill Superintendent, Cons. Arizona Smelting Co.
- Christian, Otto B.....Butte, Montana
Surveyor, A. C. M. Company.
- Clinch, Walter D.....Butte, Montana
Asst. Surveyor, U. S. Forestry Service.
- Cohan, Jesse E.....Butte, Montana
Mining Engineer, Timber Butte Mill.
- Cooke, Hamilton, Jr.....Butte, Montana
Metallurgical Clerk, Timber Butte Milling Co.
- Cullity, Emmet R.....Beaver Lake, via Le Pas, Saskatchewan
*Supt. Beaver Lake Gold Mining Co.
 Crittenden-Cullity, Mining Engineers.*
- Fowler, George M.....Butte, Montana
Mining Engineer.
- Gidel, Murl H.....Butte, Montana
Assistant Geologist, A. C. M. Co.
- Giovanetti, Ettore.....Butte, Montana
Instructor, Butte Business College.

Grupe, Charles W.....	Fairview, Nevada
<i>Millman, Nevada Hills Mining Co.</i>	
Pilger, Theo F.....	Butte, Montana
<i>Roach & Pilger, Real Estate and Mines.</i>	
Williams, Paul.....	Butte, Montana
<i>Sampler, North Butte Mining Co.</i>	

CLASS OF 1913.

Crittenden, Zar T.....	Beaver Lake, Saskatchewan
<i>Crittenden & Cullity, Engineering and Assaying.</i>	
Dobson, Chris. G.....	Butte, Montana
<i>Assistant Engineer Original Mine, A. C. M. Co.</i>	
Hanson, Wilbur W.....	Butte, Montana
<i>Engineer, A. C. M. Co.</i>	
McCool, Edward J.....	Butte, Montana
<i>Engineering Dep't., A. C. M. Co.</i>	
Manwaring, Joe H.....	Butte, Montana
<i>Superintendent, Butte-Ballaklava Copper Co.</i>	
Newton, Lucian.....	Butte, Montana
<i>Leasor, Butte-Ballaklava Mine.</i>	
Pierse, Edwin A.....	Great Falls, Montana
<i>Sales Manager, Standard Garage Company.</i>	
Pratt, A. F.....	Portland, Oregon
Reid, Milton A.....	Anaconda, Montana
<i>Testing Engineer, Washoe Smelter, A. C. M. Co.</i>	

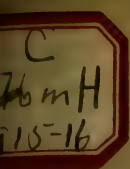
CLASS OF 1914.

Cole, Robert J.....	Seattle, Washington
<i>Engineer, Monetary and Appraisal Dep't., the Pacific Telephone & Telegraph Co.</i>	
<i>Engineer, The Quartz Creek Mining Co., Valdez, Alaska.</i>	
Lyden, Joseph P.....	Butte, Montana
<i>Assistant Geologist, A. C. M. Co.</i>	
McMahon, Brandon.....	Butte, Montana
<i>Draughtsman, C., M. & St. P. Electrical Department.</i>	
MacPherson, Frank H.....	Butte, Montana
<i>Leonard Mine.</i>	
Murphy, Joseph G.....	Seattle, Washington
<i>Licensor U. S. Land Office.</i>	
Ternouth, Blaine.....	Butte, Montana
<i>Leonard Compressor Plant, A. C. M. Co.</i>	

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UNIVERSITY OF MONTANA

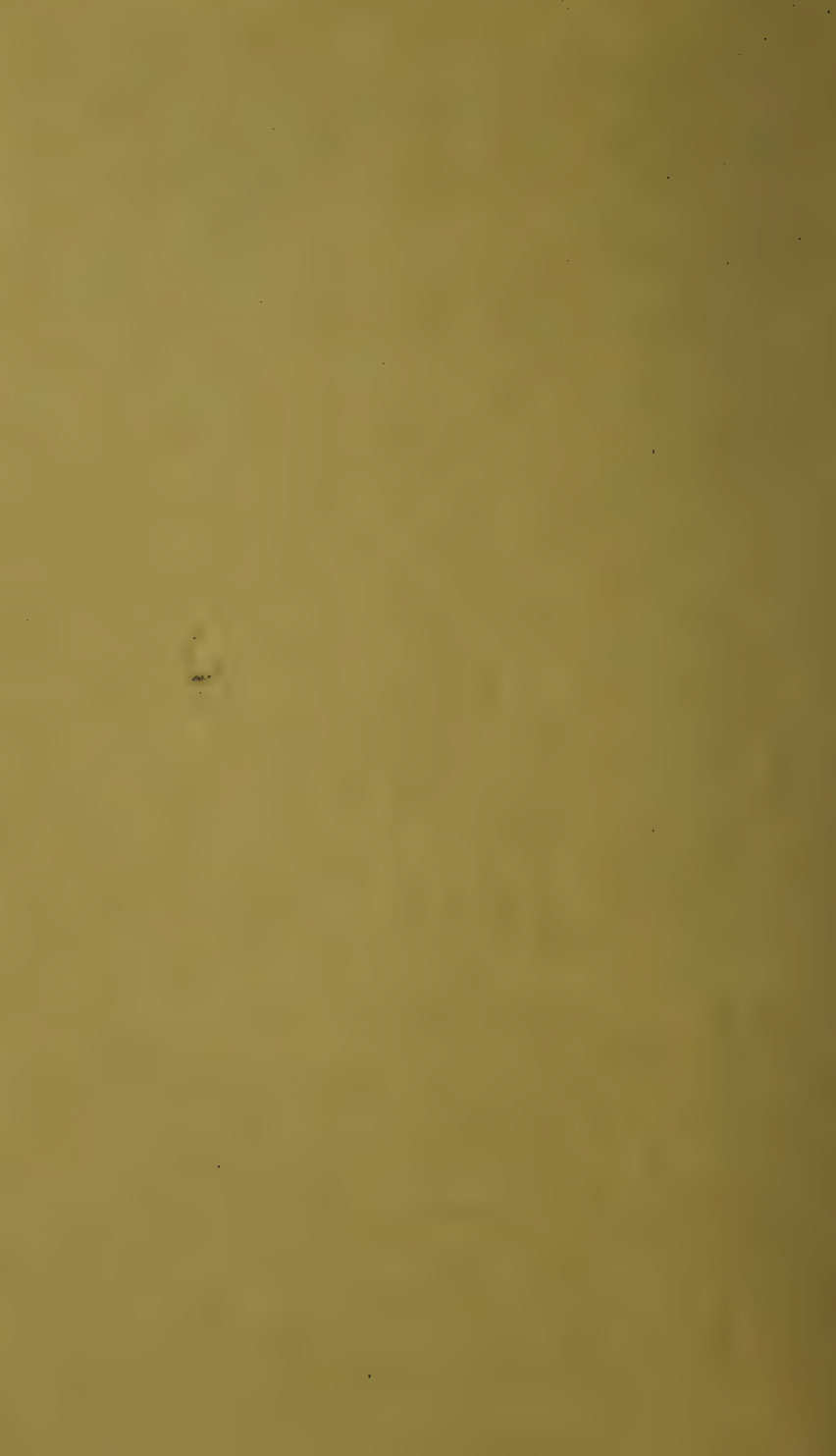
MONTANA STATE
SCHOOL OF MINES

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BUTTE, MONTANA

1916-1917



Montana State School of Mines

BUTTE, MONTANA

AUG 20 1916

FOURTEENTH ANNUAL CATALOGUE

OF OFFICERS AND STUDENTS

FOR THE YEAR

1915-1916

WITH ANNOUNCEMENTS FOR THE YEAR

1916-1917

THE UNIVERSITY OF MONTANA

The University of Montana is constituted under the provisions of Chapter 92 of the Laws of the Thirteenth Legislative Assembly, March 14, 1913 (effective July 1, 1913).

The general control and supervision of the University is vested in the State Board of Education. The Chancellor of the University is the chief executive officer. For each of the component institutions there is a local executive board.

Montana State Board of Education

S. V. STEWART, Governor	-	-	-	-	-	Ex-officio, President
J. B. POINDEXTER, Attorney General	-	-	-	-	-	Ex-Officio
H. A. DAVEE, Supt. of Pub. Instruction	-	-	-	-	-	Ex-Officio, Secretary
S. D. LARGENT	(1916)			J. BRUCE KREMER	(1918)	
W. S. HARTMAN	(1916)			C. H. HALL	(1918)	
JOHN DIETRICH	(1917)			LEO FAUST	(1919)	
A. L. STONE	(1917)			W. H. NYE	(1919)	

EDWARD C. ELLIOTT, Chancellor of the University

The University comprises the following institutions, schools and departments:

THE STATE UNIVERSITY at Missoula.

Established February, 1893, and consisting of

The College of Arts and Sciences,
 The School of Law,
 The School of Pharmacy,
 The School of Forestry,
 The School of Journalism,
 The School of Music,
 The Summer Session,
 The Biological Station, (Flathead Lake)
 The Extension Service,
 The Graduate Department.

FREDERICK C. SCHEUCH, Acting President.

THE COLLEGE OF AGRICULTURE AND MECHANIC ARTS at Bozeman.

Established February 16, 1893, and consisting of:

The College of Agriculture,
 The College of Engineering,
 The College of Applied Science,
 The College of Industrial Arts,
 The School of Home Economics,
 The School of Mechanic Arts,
 The School of Agriculture,
 The School of Art,
 The Secretarial Course,
 The School of Music,
 The Summer Session,
 The Agricultural Experiment Station,
 The Agricultural Extension Service.
 JAMES M. HAMILTON, President.

THE STATE SCHOOL OF MINES at Butte.

Established February 17, 1893.

CHARLES H. BOWMAN, President.

THE STATE NORMAL COLLEGE at Dillon.

Established February 23, 1893, and consisting of:

The Two-year Elementary Course,
 The Three-year Course,
 The Four-year Course,
 The Graduate Course.

JOSEPH E. MONROE, President.

For publications and detailed information concerning the different schools and colleges, address the President of the particular institution concerned. Communications intended for the Chancellor of the University should be addressed to the State Capitol, Helena, Montana.

SCHOOL CALENDAR 1916-1917.

1916

September 5, First Semester begins.
November 10, Close of First Term.
November 13, Second Term, First Semester begins.
Nov. 30-Dec. 1, Thanksgiving Recess.
December 22, Holiday Recess begins.

1917

January 2, Holiday Recess ends.
January 1, End of First Semester.
January 22, Second Semester begins.
March 30, End of First Term, Second Semester.
April 2, Second Term, Second Semester begins.
June 1, Commencement Day.
September 4, First Semester begins.

EXECUTIVE BOARD

CHARLES H. BOWMAN

President Ex-Officio, and Treasurer.

B. H. DUNSHEE

Secretary.

OSCAR ROHN

1916.	1917	1918
JULY	JANUARY	JANUARY
S M T W T F S	S M T W T F S	S M T W T F S
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AUGUST	FEBRUARY	FEBRUARY
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SEPTEMBER	MARCH	MARCH
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OCTOBER	APRIL	APRIL
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NOVEMBER	MAY	MAY
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DECEMBER	JUNE	JUNE
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THE FACULTY

CHARLES H. BOWMAN, M. S.,
President.

GEORGE W. CRAVEN, B. S.,
Professor of Mathematics and Mechanics.

THEODORE SIMONS, E. M., C. E.,
Professor of Mining Engineering.

D. C. BARD, A. B.,
Professor of Geology and Mineralogy.

LESTER J. HARTZELL, E. M.,
Professor of Chemistry.

BANCROFT GORE, A. B.,
Professor of Metallurgy.

EDWARD B. HOWELL, A. M., LL. B.,
Lecturer on Mining Law.

ARTHUR E. ADAMI, E. M.,
Assistant Professor of Mining Engineering.

CHARLOTTE RUSSELL,
Librarian and Registrar.

M. F. HALEY,
Assistant Millman.

MONTANA STATE SCHOOL OF MINES

HISTORICAL SKETCH.

The "Enabling Act," which paved the way for the admission of Montana into the Union as a State, contained a provision for a donation of public land for the establishment and maintenance of a state school of mines. The grant provided one hundred thousand acres to be sold at not less than ten dollars per acre, thus insuring ultimately a fund of one million dollars. The date of this act was February 22, 1889. It is a significant date as it marks the first national provision for education in the interests of the mining industry. This legislation was the natural sequel to the Morrill Act of 1862, which provided for the establishment and maintenance of state colleges for education in agricultural and the mechanic arts. Mining and agriculture stand pre-eminent as factors in the development of the resources of the country and the growth of the nation in wealth and power. It was an enlightened statesmanship that dictated these two systems of education as the best means to secure the interests of the entire people.

The First Legislative Assembly of the State appointed commissioners to select these lands. They are located mainly in the northwest quarter of the State, and for this reason are not yet salable at the minimum price fixed by Congress, but the prospective increase in immigration following the development of the extensive system of irrigation planned for our State will soon place some of these lands above the minimum value.

ORGANIZATION.

The control of the entire school system of public education in the State of Montana is vested, by the Constitution, in the State Board of Education. This Board consists of the Chancellor of the University, Governor of the State, the Attorney General, and the State Superintendent of Public Instruction, together with eight members who are appointed by the Governor. These appointments are confirmed by the Senate and hold for four years.

The immediate supervision of the school is committed to the Board of Control, consisting of the President of the school and two members appointed by the Governor of the State. It is the duty of this Board of Control to adopt a course of study, elect all members of the faculty, and pass on all financial transactions. The acts of this Board are subject to the approval of the State Board of Education and State Board of Examiners.

LOCATION.

The Montana State School of Mines is located in Butte just inside the city limits on the west. The site on the southern bench of "Big Butte," the extinct volcano from which the city takes its name, was donated by certain public-spirited citizens. It is easily accessible, one of the lines of the street railway company running within a few blocks. The location is most commanding and the view from the grounds overlooks the city, mines, and smelters, as well as the mountains which form the continental divide and which surround the valley on the east and south.

BUTTE.

It is no longer necessary to call attention to the fact that Butte is one of the greatest mining centers of the

world. The discoveries and developments of the years past and the enormous investment of capital in the mines of this city by the leading financiers and mining men of this country and Europe have given this locality such publicity that no one now needs to be told of its leading position in the mining world.

The great reduction plants that have heretofore handled the ore that comes from the mines of this city are being enlarged to treat the increased product. The modern devices for reducing the expense of treatment will be developed on a larger scale, and all of this increase in every department of the mining industry goes to render this place the more desirable as a location for a mining school.

In a very important sense all these mining plants of every description are a part of the substantial equipment of the school, because its pupils are brought into daily contact with the men who are personally engaged in the various departments of this industry and are thoroughly conversant with the details of the work.

EXCURSIONS.

To secure a more thorough and practical acquaintance with the subjects taught in the School of Mines, frequent excursions are made to some of the extensive mining and metallurgical plants in the vicinity of the School.

It is believed that the location of the Montana State School of Mines is unrivalled in the opportunities it offers for such excursions. While in most other mining schools a journey of several hundred miles must be made, at heavy expense to the student, if he wishes to investigate the practical application of the methods and processes employed in the mine and smelter, the opportunity is here presented for daily observation of work,

the development and product of which have given to Butte the reputation of being the greatest mining center in the world.

These excursions are made by the students of the School under the guidance of instructors, at such times in their course as may be most advantageous to them; but, besides these regular occasions, through the kindness of the managers of the various plants, whenever an operation of unusual interest or importance is about to take place, permission is given to the mining classes to witness the same, under the guidance of their instructors.

Short excursions are also made from time to time to regions near by which illustrate the geological features of the Rocky Mountain system.

In addition to these comparatively short excursions, the sophomores spend eight weeks in the field, where they are given fifteen hours per week in learning the use of surveying instruments, and in such exercises as are detailed under special description of courses. The juniors in like manner spend fifteen hours per week for eight weeks in underground surveys, in the mines, under the direction of the professor in charge of mining engineering, and in map drawing to show underground workings. In like manner the junior spends four weeks making geological surveys in several of the interesting fields of this and adjoining States.

Through the courtesy of the great mining companies, as well as the smaller operators, and individual miners, the students of the School of Mines have every proper opportunity of visiting these mining plants and observing the operations therein conducted. The great practical advantage that thus accrues to the mining student cannot be overestimated.

BUILDINGS.

In 1895 a Building Commission was appointed and authorized by the Legislature to issue bonds, the proceeds of which were to be used for the erection of a suitable building for the School. The issue of bonds returned the amount of \$120,000.00, and during 1895 and 1897 a four-story pressed brick building was erected. This main building measures one hundred and eighteen feet along the front; the depth is ninety-four feet. There are 37,000 square feet of floor space utilized in class rooms, laboratories, etc. The basement floor is given up to chemical and metallurgical laboratories and to a mechanical testing laboratory. The next two floors contain the recitation rooms, the drafting rooms, the mineralogy laboratory and the library. The fourth floor is given up mainly to museums containing extensive collections of minerals, mine models and exhibits illustrating geology. There is also a petrographic laboratory on this floor where ample table room is supplied together with requisite cabinets of rock specimens, thin sections, etc.; the laboratory contains the machines necessary to cut rock and mineral sections.

The Legislative Assembly of 1907 appropriated \$59,000.00 for a new heating plant and an additional building to be equipped as an ore-dressing and metallurgical plant. The second building was completed in 1908, and measures 70 feet by 110 feet. The building is now equipped to handle large quantities of ore conveniently, offering treatment by most of the standard processes now in practice, a detailed account of which may be found under the proper heading. The mill building contains the steam and electric power plant which supplies power to the mill and affords a fine laboratory in this line for instruction and practice for the students.

The gymnasium building is the latest acquisition to the

school's equipment, being erected in 1910. It is constructed along the established line of architecture, and measures 87 feet by 50 feet. The building contains one large gymnasium hall 70 feet by 45 feet, at one end of which is a balcony with a seating capacity for 100 people. The hall may also be used as a general auditorium on special occasions. Connected with the gymnasium are two parlors, a dressing room, and in the basement a room equipped with shower baths, toilets, etc.

MAINTENANCE.

The maintenance of the Montana State School of Mines is provided for by the State through biennial appropriations made by the Legislative Assembly. The sum provided for the biennium ending February 28, 1917, is \$70,000.

The aim of the Montana State School of Mines is to furnish the best possible education to those whose life work will be devoted to mining in any of its branches. The School is therefore wholly a technical one, not providing an education for the business man, the farmer, or the literary man, but confining its energies entirely to the proper mental equipment of mining men. The course of study, which is fully described in the following pages, has been elaborated with this purpose constantly in mind.

REQUIREMENTS FOR ADMISSION.

The Montana State School of Mines is open to residents of Montana and to residents of other states and countries regardless of sex or race, on terms prescribed by the Board of Trustees, provided they are qualified to pursue the studies enumerated on the following pages.

Fifteen units are required for admission to the freshman class. One unit represents nine months' work with not less than five forty-five minute periods per week; two

laboratory, shop, or drawing periods are considered equal to one recitation.

Of the fifteen units required, three are required in mathematics, distributed between algebra and plane and solid geometry; three are required in English composition and literature; and one is required in physics. The remaining eight credits are to be selected from history, modern languages, Latin, elementary science, and manual training.

Candidates for admission who are graduates from an accredited high school will have complied with the above requirements and may be admitted upon presentation of the proper certificate of graduation.

Candidates who have prepared at other institutions of learning are required to bring all grade cards, certificates or diplomas they may possess to be submitted to the Faculty for approval. The right is reserved to examine such candidates in any or all subjects submitted for credit.

Applicants for admission to any of the advanced classes may be required to pass a satisfactory examination in all studies required in the classes preceding the one they desire to enter. Credit will be given for the work done in other institutions of recognized rank, provided the candidate can furnish satisfactory proof of having received a passing mark in the work pursued in such institution before leaving. In all cases such students are required to furnish a certificate of honorable dismissal from the institution from which they come.

Persons of mature years who have had experience in some of the branches of mining and metallurgy and who are not candidates for a degree may be admitted to any of the classes they may select on giving satisfactory evidence of their preparation to pursue their studies with profit to themselves and without embarrassment to the classes.

ACCREDITED HIGH SCHOOLS OF MONTANA.

City High Schools.

Anaconda	Fromberg	Pony
Baker	Glasgow	Ravalli
Belt	Great Falls	Roundup
Belgrade	Hamilton	Shelby
Billings	Harlowtown	Sheridan
Bridger	Havre	Sidney
Butte	Helena	Stanford
Chinook	Hysham	Stevensville
Columbia Falls	Joliet	Terry
Columbus	Laurel	Thompson Falls
Conrad	Libby	Three Forks
Corvallis	Manhattan	Valier
Culbertson	Moore	Victor
Cutbank	Plains	Virginia City
Eureka	Polson	Whitefish
Forsyth		Whitehall
Worden		White Sulphur Springs

County High Schools.

Beaverhead	Fergus	Park
Broadwater	Flathead	Powell
Carbon	Gallatin	Sweet Grass
Choteau	Granite	Teton
Custer	Jefferson	Wibaux
Dawson	Missoula	

REQUIREMENTS FOR GRADUATION.

The School confers the degree of Mining Engineer upon those who have completed the course as outlined in the following pages.

Students who finish a certain part of the course, such as surveying, assaying, or mechanical drawing, will receive certificates stating what work they have completed.

EXPENSES.

Fees.—By the Act establishing the School of Mines, no charge of tuition is to be made where the student is a bona fide resident of Montana. Students from other states or countries will pay a tuition fee of \$25.00 per semester, or \$50.00 per year.

A registration fee of \$5.00 each semester will be required of all students. No deduction will be made to those who attend for only part of the semester.

Deposits.—To secure the State against loss for apparatus that may be broken or damaged by the students, a deposit is required at the beginning of the year from each one engaged in laboratory work.

This deposit is placed in the hands of the Treasurer of the Board of Trustees. Each student is charged with the apparatus issued to him. At the close of the year he is credited with such articles as he returns in good order, and the balance of this account is then returned to him.

The following is the list of deposits that are required:

FRESHMAN YEAR.

General Chemistry and Qualitative Analysis.....	\$15.00
Mine Surveying	\$10.00

SOPHOMORE YEAR.

Quantitative Analysis	\$15.00
Mineralogy	5.00
Deposit for Platinum Ware	30.00

JUNIOR YEAR.

Mine Surveying	\$10.00
Assaying	10.00

SENIOR YEAR.

Metallurgy	\$15.00
Petrography	10.00

When the breakage exceeds the deposits the student will be required to make good the full amount of the damage done.

There are no dormitories connected with the School. Students will be expected to find board and lodging for themselves in Butte or its vicinity, and at such places as approved by the faculty. The expense for board and lodging is not higher than in other important cities of the West. Good board can be secured at \$25.00 per month, while the cost of a good room large enough for two persons and including light and heat will be from \$15.00 to \$25.00 per month, according to location and the furnishings. Cost of text-books average about \$25.00 a year. For those who find it necessary to economize, there are few cities that afford as favorable opportunities for self-help as are found here.

COURSE OF STUDY

FRESHMAN YEAR.

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Higher Algebra	3	3
Trigonometry	5	5
Chemistry Lectures	3	3
Chemistry Laboratory	6	6
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	9	9

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Analytical Geometry	5	5
Plane Surveying, Theory	3	3
Descriptive Geometry	2	2
Chemistry Lectures	3	3
English	2	2
Chemistry Laboratory	9	9
Mechanical Drawing	6	6
Plane Surveying, Field Work, Summer Course of Four Weeks		

SOPHOMORE YEAR

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Chemistry Laboratory	6	9
Mineralogy, Lectures	2	2
Mineralogy, Laboratory	0	6
Topographical Drawing	9	0

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Calculus, Anal. Mechanics.....	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory	2	2
Mineralogy, Lectures	3	0
Geology, Lectures	0	3
Mineralogy, Laboratory	6	6

JUNIOR YEAR

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice	15	0
Engineering Design	0	9
Graphics	0	6

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Mechanics and Hydraulics	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	3
Geology, Field Work	3	3
Assaying	6	6
Mining, Laboratory	0	3

SENIOR YEAR

FIRST SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Geology	5	5
Mining	2	3
Ore Dressing	0	2
Metallurgy	3	2
Mechanical Engineering	5	3
Geology, Field Work.....	0	3
Metallurgical, Laboratory	15	6
Engineering Design	0	6

SECOND SEMESTER.

	First Term. Hours per Week.	Second Term. Hours per Week.
Mining	3	3
Ore Dressing	2	2
Metallurgy	3	3
Metallurgy, Laboratory	6	6
Power Transmission	3	3
Engineering Construction	2	2
Engineering Design	6	6
Petrography	5	5
Mining Law	2	0

ENGLISH

PROFESSOR C. H. BOWMAN.

Two hours per week during the Freshman year are allotted to the study of English composition. The work is designed to continue the training outlined in the usual high school course, the chief aim being to create an individual and effective means of expression and communication for the ordinary demands of professional life. The ability to express oneself accurately and with some degree of elegance is an advantage which is not easily overestimated. At the same time the stimulating of literary sympathy and appreciation is kept in view, this we deem especially desirable in a professional course, as it supplies an element which is a source of pleasure in after life.

The work begins with a series of classroom lectures and discussions during which time the students are given simple exercises in writing; special attention is given to grammar, punctuation, choice of words, etc. Finally this work is extended to the study of the paragraph and the more complete theme.

During the latter part of the year the class is organized to develop the debate together with the regular theme writing. Proper form and fluency in speaking to an audience is a matter cultivated throughout the year. Among the other helpful features of the course may be mentioned a thorough and practical drill in parliamentary law, instruction on note taking, on making outlines, on writing examination papers and on the use of the library. The reading assignments for critical study are drawn mainly from the best technical magazines, from the best editorials, while occasionally a book of purely literary merit is assigned for review.

MATHEMATICS

PROFESSORS CRAVEN AND BOWMAN, ASST. PROFESSOR ADAMI.

Algebra.—A preliminary course is first given designed to drill the student in the fundamental algebraic operations and in the statement and solution of simple mechanical problems. This review is followed for the remainder of the semester by a careful study of those operations of advanced algebra which will be of use to the student in future engineering courses. Special attention is given to the theory and use of exponents and logarithms, simultaneous quadratic equations, the more common series with their practical applications, indeterminate coefficients and quantics solved by synthetic division and by graphical methods. Text, "Wentworth's College Algebra."

Freshman first semester, three hours per week.

Trigonometry.—In plane trigonometry the subjects of primary importance are: Goniometry; solutions of right and

oblique triangles; practical problems. The solution of the right and oblique spherical triangles is developed and practical application is made to surveying and mensuration. The text used is Wentworth's "Plane and Spherical Trigonometry."

Freshman, first semester, five hours per week.

Analytical Geometry.—This course from its very nature becomes a thorough review of algebra, geometry, and trigonometry. The material gathered from these three sources is combined in a most striking way which leads to a more practical working knowledge of these branches of mathematics. The student is required to study and plot accurately numerous problems covering such topics as, the point and straight line in a plane, different systems of co-ordinates, conic sections, higher plane curves, the point and straight line in space, curved surfaces, and surfaces of revolution. Toward the end of the course the student is required to study various mechanical movements, to devise movements and to determine the laws and equations involved. Text, "Analytical Geometry," by H. B. Philips.

Freshman, second semester, five hours per week.

Calculus.—Among the topics studied in this course may be mentioned differentiations, tangents, normals, subtangents, subnormals, asymptotes, indeterminate forms, logarithms, maximi and minima, curve tracing, integration, rectification of curves, areas, volumes, center of mass, moment of inertia, and work. The text used is Taylor's "Differential and Integral Calculus."

Sophomores, throughout the year, five hours per week.

GEOLOGY AND MINERALOGY

PROFESSOR BARD.

The geological side of engineering is presented to the student through courses in Mineralogy, Geology and Petrography.

Mineralogy.—Text book is Rogers' "Study of Minerals." The purpose of this course is to familiarize the student with about two hundred of the commoner minerals, especially those of economic importance. Methods of determination are presented by the aid of Crystallography, Blowpipe Analysis, and by comparison with known mineral specimens. Thus the course involves lectures, laboratory practice and museum study. Accuracy and rapidity in determining minerals by means of physical and chemical tests is the object sought. Some lectures are devoted to describing the value and mode of occurrence of the more important minerals. Short field trips for the purpose of collecting minerals and observing their mode of occurrence are a part of the course.

Crystallography is studied with a view to familiarize the student with the principles of the subject and to enable him to identify crystallographic forms and their combinations. The work consists of lectures, supplemented by laboratory practice in the identification of natural crystals and models. This course is introductory to that in determinative mineralogy.

The time given to blowpipe analysis is devoted mainly to laboratory work. Informal lectures and recitations are held from time to time as deemed desirable. The object of the work is to teach the student to use the blowpipe and to make other tests of importance in mineralogy. The optical properties of mineral fragments are studied with petrographic microscopes.

The work in descriptive mineralogy consists of lectures, tests and laboratory work. The introductory lectures take up the character of minerals and their occurrence and origin; then follow the regular lectures describing all the more important mineral species. Special stress is laid on sight determination by requiring the examination of the museum specimens and the rapid identification of many of these specimens in class. By this means the student learns to identify typical specimens by their external appearance alone. In this manner the student becomes thoroughly familiar with the appearance, properties, associations and uses of the economically important minerals, and obtains some insight into the practical and scientific problems connected with mineralogy.

The final and most important work in the course consists of laboratory work in the identification of mineral species. Thus the operations and principles previously studied are used in a practical way.

Sophomores, first semester, first term, two hours per week.
Sophomores, first semester, second term, eight hours per week.
Sophomores, second semester, first term, nine hours per week.
Sophomores, second semester, second term, six hours per week.

Geology.—The principles of geology are developed through lectures, field excursions and laboratory exercises. Physiographic, dynamic and structural geology are first studied, followed by a brief outline of historical geology. The needs of the mining engineer are kept constantly in mind and numerous illustrations are given showing where geologic principles may be applied to practical problems. Montana geology is given particular attention. Textbook is Ries & Watson's "Engineering Geology."

Sophomores, second semester, second term, three hours per week.
Juniors, first semester, five hours per week.
Juniors, second semester, first term, eight hours per week.

Economic Geology.—This course takes up the principles of mineral disposition, both metallic and non-metallic, geologic relations, commercial value and geographic distribution of the more important mineral districts are considered. Field

trips are made to mines and quarries to supplement the lecture work. The textbook used is Lindgren's "Mineral Deposits," supplemented by lecture notes.

Juniors, second semester, second term, eight hours per week.

Seniors, first semester, five hours per week.

Mining Geology.—This course consists of lectures with field and library work. Principles and practice of geologic mapping are developed. Mines in Butte and in other parts of Montana are visited, the geology is studied, and reports prepared. Systematic reports on the important mining camps of the United States are prepared from available literature.

Seniors, first semester, second term, eight hours per week.

Petrography.—A course in microscopical petrography is provided for the senior year. The principles and objects of the use of the microscope are outlined in an earlier course. "Minerals in Rock Sections," by L. M. Luquer is used for reference. The student is taught to distinguish the commoner rock-forming minerals by microscopic methods. Practice is also given in the preparation of petrographic slides. After this the study of rocks is undertaken with the aid of lecture notes. In addition to the thin sections, megascopic specimens of the various rocks are at hand in convenient drawers and the student is required to examine these hand specimens while studying the slides. This course affords the student an opportunity to become thoroughly familiar with the megascopic and microscopic characters of the principle rock types and enables him to become acquainted with petrographical theory and its relation to certain problems in applied geology.

Seniors, second semester, five hours per week.

CHEMISTRY

PROFESSOR HARTZELL.

General Chemistry.—The subject of General Chemistry is presented by lectures and text books.

The object of the course is to develop the underlying principles of the subject as a basis for all subsequent work in the department. The student is made familiar with the principal characteristics and relations of the elements one to another, the work being illustrated by experiments conducted by the instructor. In this work the student is directed to read from text-book references, and it is essential for those who take the course to take notes on the lectures which are designed to aid and direct the work performed in laboratory practice during the semester. The text book used is "General Chemistry for Colleges," by Alexander Smith.

Freshmen, throughout the year, three hours per week.

General Chemistry, Laboratory.—The course of laboratory study in this subject consists of performing a number of experiments by the students at individual desks. This course is designed to teach the student the use of the various kinds of apparatus, chemical agents and reagents, besides becoming familiar with their reactions and relations with each other. A neatly kept note book is essential in this work, in which is kept a record of the statement, reactions and principles involved in each experiment.

*Freshmen, first semester, six hours per week.
Freshmen, second semester, nine hours per week.*

Qualitative Analysis.—This course is designed to instruct the student in the general scheme of analysis by which the different metallic elements are detected and separated from each other. The more common acid radicals, their identification and isolation also forms a part of the course.

Lectures accompany the work giving a general outline of the schemes, separations, etc., dealing with the merits and difficulties of each, finally pointing out the most satisfactory proof in each case. The essential element of writing and balancing equations is a part of the drill work in class-room exercise. Chemical Arithmetic or Stoichiometry is also taught during the latter part of the second semester.

The text book used is "Qualitative Analysis," by Prescott and Johnson.

Freshmen, second semester, three hours per week.

Quantitative Analysis.—This course is designed to meet the needs of the mining engineer in the pursuit of his profession. It embraces all the general analyses such, as analysis of limestone, dolomites, rock analysis, ores of iron, manganese, lead, zinc, arsenic, copper and many others such as the analysis of artificial substances, among which are given, mattes, slags, flue dust, concentrates, roasted ore (calcines) and pig iron and steel.

The subject of acidimetry and alkalimetry is taken up and explained. Analyses are made of different substances to demonstrate this subject.

The work in chemistry throughout is conducted with a view of developing rapid and accurate work on the part of the student. The problems and laboratory work are selected as far as possible from the work of the practitioner in the mining districts, especially of the West. While these practical features are employed the instructor bears it ever in mind that through all the work the student must be required to use his own talents and learn to think and reason for himself.

Sophomores, first semester, first term, two hours lecture per week and six hours laboratory.

Sophomores, first semester, second term, one hour lecture per week and nine hours laboratory.

Sophomores, second semester, one hour lecture per week and nine hours laboratory.

METALLURGY

PROFESSOR GORE, MR. HALEY.

Introduction to Metallurgy.—The study of Metallurgy begins with lectures and recitations on the fundamental principles of the science. The student is familiarized with the names and properties of the commoner metallurgical products. The principles of ore treatment by mechanical and smelting methods are discussed in a general way, leaving the more detailed study of the various processes till later in the course. The principles of combustion, amount of air required, heat carried away by gases, products of combustion, etc., are studied. The various fuel, solid, liquid and gaseous, natural and prepared, and the best way of applying them to attain the desired temperatures are considered. Following this, gas producers and various types of furnaces, i. e., blast reverberatory, muffled and electric, used in metallurgical operations are described. In connection with this, the methods for utilizing waste heat are discussed. The source and properties of the various refractory materials and their manufacture into bricks and crucibles and methods of testing are investigated.

Junior, first semester, first term, three hours per week.

Metallurgy of Copper.—The study of the metallurgy of copper is conducted by lectures and recitations covering the subject fully. The electrolytic refining of copper bullion is studied as a part of this course. Immediately after the subject is treated in the lecture and recitation rooms, one week is devoted to a practical study of the smelter and electrolytic refinery at Anaconda or at Great Falls. Each operation in the treatment of copper ores is studied in detail, among them may be mentioned the processes of concentration, the production of matte by both reverberatory and blast furnaces; the blowing of matte to metallic copper in the converter and the process of refining copper in the reverberatory refining furnace. Most of the standard methods of concentration, roasting and reduction of copper ores are studied during these visits. A typewritten report of the operations observed is required of each student. The text book used is Peter's "Practice of Copper Smelting."

Junior, first semester, second term, three hours per week.

Metallurgy of Gold and Silver.—The second semester of the junior year is devoted to the metallurgy of gold and silver. The methods of obtaining gold by dredging and sluicing are treated briefly. The larger portion of the time is taken up with a rather detailed study of the cyanide process from both a chemical and economic standpoint. The various methods of crushing, classifying and treatment of sands and the slime are treated quite fully. The modern devices for handling the sands and filtering the slimes are studied. The other metallurgical processes for silver, such as the Washoe

process and the hyposulphite lixiation process, are discussed briefly. The course is completed by a two weeks' excursion to visit the various cyanide and other plants, where a careful study is made of the process and a detailed typewritten report is made by each student. These subjects are presented through lectures and assigned reading.

Junior, second semester, three hours per week.

Metallurgy of Lead and Silver.—The subject of the metallurgy of lead is studied during the first semester of the senior year and is presented through lectures and assigned reading. The work first covers a historical sketch of the various processes and finally covers a detailed study of all the reactions, devices and processes found in the modern lead smelting plant. The processes of roasting, the blast furnace practice and the refining of bullion are given full consideration. The class is also given some experience in making all necessary calculations.

Following the course the class is taken to a lead smelter and required to make a detailed study of all departments, submitting a written report of the examinations made at the works.

*Senior, first semester, first term, three hours per week.
Senior, first semester, second term, two hours per week.*

Iron and Other Metals.—The metallurgy of iron and steel is presented through lectures and text-book study. Stoughton's Metallurgy of Iron and Steel being the text in present use. Special attention is given to the value of the various ores and the metals and other elements used in the manufacture of alloy metals. In addition to the methods of manufacture of iron and steel into the standard forms of commerce considerable attention is paid to the testing of these products and their uses.

The metallurgy of zinc is covered by a series of lectures where the processes of roasting and retort smelting are fully explained. Attention is also given to the manufacture of the retorts and other devices used about the works.

This course also includes a study of the uses of zinc, together with the uses and manufacture of its alloys.

The latter part of the senior year is taken up with a series of lectures and student reports covering the metallurgy of other metals of commercial importance; among them may be mentioned the metallurgy of tin, nickel, cadmium, aluminum, etc. The careful and thorough study of the preceding metals forms a basis of knowledge about furnaces, metallurgical reactions, etc., which permits an easy understanding of the special features involved in each of the subjects taken up in this course.

The students' part of the work is accomplished through reference to standard works and special articles found in the publications in the library.

Senior, second semester, three hours per week.

Fire Assaying.—The course in fire assaying is essentially a laboratory drill course. It comes during the Junior and Senior years when the students are familiar with the reagents and most of the chemical reactions used in the work. However, the laboratory work is preceded by a short course in lectures in which the general principles of the art are developed and all equipment carefully explained. Attention is given to the proper care of the furnace and method of controlling the temperature. The special balances used in this work are demonstrated, showing methods of operating, care and adjustments. Finally the class is given a series of notes which embody a description of the charges in actual use in the mining and smelting plants of the West.

In the laboratory work each student is given a desk with a full equipment of reagents and apparatus. Ample furnace room, balances and ore-grinding apparatus are provided so no delays are encountered through lack of equipment. Then each student works through his individual list of ores to be assayed. There are silicious oxidized ores, basic oxidized ores, ores of lead, copper and zinc; all containing various impurities. These are assayed for gold and silver and when lead is present it is also determined. The smelter products likewise receive attention; lead and copper mattes, speiss, antimonial lead, lead and copper bullion, lead and copper slags are all treated according to the custom about the laboratory of the smelter.

Both crucible and scorification methods are used where considered practicable, while the combined wet and dry methods are used upon material such as copper bullion, mattes high in copper, blister copper, etc.

The laboratory work covers about twenty weeks of two afternoons each week. Throughout the course speed and accuracy are considered essential points. Before a student is considered proficient he must be able to accomplish what may be considered a reasonable day's work in a commercial laboratory. Accuracy is required, but it is not sufficient; speed is considered equally important.

In this course no charge is made for materials or equipment except where there is an unnecessary breakage or consumption of material.

Junior, second semester, two afternoons per week.

Metallurgical Laboratory Practice.—The work of the first term of the Senior year includes the systematic investigation of a large variety of commercial ores for the purpose of determining in each case the most economical metallurgical process for the recovery of the precious or base metals. In connection with this work the students have access to special laboratory equipment of the most approved type for ore testing on a miniature scale. Recent additions to this laboratory include a slide-testing machine for the study on a reduced scale of the oil-flotation process; a large porcelain

pebble mill for all-sliming operations, grinding in solution and chlorination work; special air agitation apparatus for the cyanide treatment of refractory ores and concentrates; individual vacuum filters and a small Kelly filter press for the study of problems involving slime filtration and washing.

A small lot of uncrushed ore, generally not less than fifty pounds, is given to each student, who first makes a careful physical examination indicating the minerals containing the precious or base metals, those composing the gangue, nature of the ore and such characteristics as might have a bearing on the particular line of investigation to be followed. An accurate sample is then prepared, assayed and analyzed for the usual constituents determined in metallurgical practice. A scheme of treatment is then outlined and the results obtained are systematically tabulated, forming the basis of an individual report on the economical treatment of the ore in question.

Experience gained in previous years' work in mineralogy assaying and metallurgical analysis is made frequent use of in this course and accordingly no student will be admitted unless qualified in these subjects.

Special emphasis will be given to processes of current interest open to important future developments such as the recovery of values from refractory gold and silver ores and concentrates, oil flotation methods and hydrometallurgical treatment of copper ores. There is practice work in amalgamation, concentration, chloridizing roasting, hyposulphite leaching, magnetic separation and dry chlorination.

Senior, first semester, first term, five afternoons per week.

Metallurgical Mill Practice.—Data obtained in the metallurgical laboratory during the first semester forms the basis of actual mill tests during the balance of the school year, the aim being to duplicate on a commercial scale the results previously obtained from laboratory samples.

For this work there are crushers, rolls, mills, etc., so arranged as to reduce the handling of the ore to a minimum.

A battery of three stamps offers practice in stamp milling during which tests the class is given practice in dressing the plates and recovering the bullion. Other tests involve the use of amalgamating pans, cyanide vats of three tons capacity, a slime and agitation equipment, a lead lined agitation barrel for chlorination work. There are also roasting furnaces with which any of the roasting operations may be carried out that are required in the standard processes of ore treatment.

During this work much attention is given to the handling and adjusting of machinery. Under proper instruction the students operate the mill from the power plant to the tailings dump. This experience is a valuable asset to any young engineer undertaking work, especially with the smaller plants of the west, since mining engineers, even if they are not

metallurgists, are frequently called on to operate ore dressing or milling plants. The course also gives excellent opportunity for gaining experience in methods of sampling.

One hour each week is devoted to a discussion of the principles involved in each of the milling operations and individual reports are read and commented upon.

*Seniors, first semester, second term, two afternoons per week.
Seniors, second semester, two afternoons per week, conferences one hour per week.*

MECHANICS

PROFESSORS CRAVEN AND BOWMAN.

Physics.—Throughout the course in physics the student's attention is directed to a systematic development of the principles of the science. These he must study and in connection solve numerous problems. He must also attend lectures and demonstrations in which the phenomena are shown and finally enter the laboratory and make a series of physical measurements. While the general subject of physics is covered, it is the aim to develop most thoroughly such parts as add directly to the working knowledge of the mining engineer.

During the first semester the student acquires an analytical knowledge of the mechanics of solids and fluids. Principles and fundamental methods are considered of great importance in this elementary course. Among the topics considered may be mentioned: Concurrent and parallel forces; center of gravity; resistance and work; simple machines; gravity and motion; inertia and rotation. A series of about 400 problems is solved during this course. In the mechanics of fluids the fundamental principles are developed through a series of lecture demonstrations. During the latter part of the semester the subject of heat is introduced; aside from the nature and measurement of heat, its application to the steam engine and to the transmission of energy by means of compressed air is considered. The text-book used is "Elements of Mechanics," by Merriman.

Sophomores, first semester, six hours per week.

Physics.—The second course in physics includes a thorough study of the elements of electricity and magnetism and a brief study of light and sound. The principles and application of electricity to dynamos, motors, the transmission of energy, lighting, etc., are most essential parts of the course. The work in light includes a study of optical instruments and of the phenomena met in the study of mineralogy and petrography.

During the last term of the semester the class work of the year is supplemented by practice, four hours per week, in the laboratory. Constants in the domain of mechanics and

heat are determined, and a familiarity is acquired with simple electrical measurements, the running and behavior of dynamos and motors, etc. "Elementary Lessons in Electricity and Magnetism," by Jackson, is used as a text book.

Sophomores, second semester, four hours per week.

Applied Mechanics.—This course is a sequence to the analytical mechanics which is made a part of the integral calculus. The laws of elasticity and resistance of materials are studied and applied to the proportioning of pipes; cylinders and riveted joints; the general theory of beams; cantilever beams; and continuous and restrained beams. In this work the graphical solutions are developed as well as the analytical solutions. The application to columns or struts is developed and to shafting for transmitting power. Finally a number of special subjects are taken up which are of interest to the engineer, such as resilience and work, impact and fatigue, true and internal stresses. Throughout the course numerous problems are solved selected from engineering practice and illustrating the theory developed. The course also includes a study of the properties and uses of various building materials, the metals, timber, stone, brick, cement, etc.

It is the object of this course to direct the student's attention to the elements of design of mining machinery. It is necessary to devote a considerable portion of the time to the study of simple mechanisms, such as screws, nuts, bolts, keys, pipes and pipe fittings, shafting, couplings, support for shafts, etc. A study is also made of gearing, outlines of gear teeth, cams, linkwork, belts, rope gearing, etc. The application of mining machinery is found in the catalogues furnished by manufacturers. Special attention is given to the installation and maintenance of machinery, and in this connection a great deal of practical information is obtained by frequent visits about the repair shops of the mines of Butte. Merriman's "Mechanics of Materials" is used as a text book.

Junior, first semester, five hours per week.

Junior, second semester, two hours per week.

Hydraulics.—A knowledge of the subject of hydraulics is of importance to the mining engineer, especially to the engineer whose field of labor is in the West. The course is introduced with a brief review of hydrostatics and theoretical hydraulics. A systematic study is then made of problems involved in the study of the flow of water through orifices, over weirs, through pipes and conduits. Attention is given to the elements of design of dams for water supply and for mining and other purposes. The immense use of water power for mining purposes prompts an investigation of the various turbines and impulse wheels. Merriman's "Treatise on Hydraulics" is used as the text book.

Junior, second semester, three hours per week.

Mechanical Engineering of Power Plants.—The discussion of the power plant is preceded by a course of lectures and recitations on Thermodynamics. Attention is paid to definitions and units in the domain of heat, work, and power. The laws of thermodynamics are thoroughly developed and numerous related problems are solved. Following this course, a systematic study is made of the mechanism of engines, non-condensing, condensing, simple and continuous expansion engines, valves, and valve gearing with their various governing attachments, engine foundations, bed-plates, etc. Steam boiler types are studied together with their setting, management, etc. The designing and construction of chimneys and the general plans for power house are also made a part of this course. The text book used is "Steam Engines and Boilers," by Kinealy.

During this course a series of lectures is offered, essentially descriptive of pumps and pump details, special attention being given to the construction and management of mining pumps. The course is based on "Pumping Machinery," by William M. Barr.

Senior, first semester, second term, three hours per week.

Senior, first semester, first term, five hours per week.

Power Transmission.—The extensive use of electrical power, together with the abundant water supply for power inclined chords and continuous trusses. In these problems tended attention to this branch of engineering. The elementary principles are laid down during the sophomore year. In the senior year the student's attention is directed to the general conditions of power transmissions, power transmission by continuous current, some properties of alternating currents; power transmission by alternating currents, synchronous and induction motors, current reorganizers, hydraulic development, the organization of a power station, line construction, centers of distribution, the commercial problems, and measurement of electrical energy. The numerous electrical plants about Butte offer opportunities for observing most excellent practice in this line of engineering. The text book used is "Power Transmission," by Bell.

Senior, second semester, three hours per week.

Graphics.—The work in Graphics follows the Junior course in mechanics. The course is intended to familiarize the student with graphical methods of obtaining the stresses in the members of any of the common structures intended to support a load above an opening—a roof, bridge or truss. A detailed study is made of the proportions of the various standard roof trusses, attention being given to loads due to materials, wind, snow, etc. Analysis is made of single-span trusses of various types with horizontal chords, trusses with inclined chord, and continuous trusses. In these problems concentrated and uniform loads are considered, stresses due

to a locomotive, also stresses due to the wind, etc. The work is carried out in the drawing room, supplemented by lectures and recitations. "Steel Mill Buildings," by Ketchum, is used as a basis. Twelve practical problems are presented and solved in the drawing room.

Junior, first semester, second term, six hours per week.

Engineering Construction.—This course consists of lectures and recitations on modern practice in engineering construction. Among the subjects covered may be mentioned: Details of mill building, both frame and steel; construction of retaining walls, foundations, dams, etc., cement, reinforced concrete. The lectures deal with the many practical points in construction and in the handling and care of material. The text book used is Ketchum's "Steel Mill Buildings."

Senior, second semester, two hours per week.

MECHANICAL DRAWING AND MACHINE DESIGN

PROFESSOR CRAVEN, ASSISTANT PROFESSOR ADAMI.

Mechanical Drawing.—The primary object of instruction in mechanical drawing is to lay the foundation for the skill, neatness and speed necessary to pursue the subsequent courses. The beginner in this subject should supply himself with first-class instruments; a good set will serve him for years after his course in school is completed, while an inferior set will cause annoyance and loss of time almost from the beginning. The student should consult the instructor in charge in regard to the kind and number of instruments necessary.

Throughout this course the student applies himself in the drawing room, becoming familiar with the use of drawing instruments and the elements of projections and sections. He is required to complete a given number of plates, drawing the projections, sections, and intersections of simple objects which are merely described to him. While the instructor is always present to assist and see that no time is lost in useless endeavor, it is the aim to guard against the copying of drawings; the student must learn to think and construct for himself. A short time of each period is given to the rapid drawing of problems previously assigned in descriptive geometry. The course also includes practice in free-hand lettering. "Mechanical Drawing," by Faunce, and "Descriptive Geometry," by Faunce, are the text books used.

Freshmen, first semester, nine hours per week.

Mechanical Drawing.—The second course in mechanical drawing continues the subject laid down in the first course. The study of descriptive geometry is completed and applied to more difficult problems. During this course the student is taught the use of water colors as applied to engineering

drawings, practice is given in coloring maps and shading parts of machine drawings. As far as possible the problems in drawings are taken from those met by the mining engineer in practice; when the student completes his course he is equipped with drawings of the standard timber sets used in mines, with drawings of shaft timbers, head frames and machine drills with the conventions used in mine and geological maps, and many other useful items used in mining.

Freshman, second semester, six hours per week.

Descriptive Geometry.—Two hours per week throughout the Freshman year are occupied with recitations in descriptive geometry. Throughout the course the students study assigned lessons from a text book, together with the notation work, etc. The class period is taken up for the most part with the working of new problems, especially those involving the point, line, and plane; it is a drill hour in rapidity and accuracy in the application of the essential features of the subject. The procedure insures a thorough mastery of all the elements, an acquisition which is of great value in much of the work of the mining engineer. It assists him in his mechanical drawing and designing, it is indispensable in many problems in mine surveying and aids greatly in part of the work in geology, especially in the practical work in mines where faults and veins are traced and platted.

In the latter part of the work where the more complicated intersections of solids and the developments of surfaces are required, the class works in the drawing room. Here the problems are likewise varied so that the possibility of merely copying or committing to memory is eliminated. The course follows in close touch with the regular mechanical drawing where the more elaborate drawings are completed, dimensioned and inked. The text used is Faunce's "Descriptive Geometry."

Freshman year, two hours per week.

SURVEYING AND TOPOGRAPHICAL DRAWING

PROFESSOR SIMON, ASSISTANT PROFESSOR ADAMI.

Plane Surveying.—Lectures and recitations, including description of surveying instruments, their construction, adjustment, use and care. Form of field notes for different methods of surveying, computation of bearings, co-ordinates, elevations, areas, quantities of material, from data secured in the field. Solution of problems in surveying, requires a thorough knowledge of algebra, geometry and trigonometry. Practical use of surveying instruments on the school grounds. Algebra, trigonometry and the use of logarithms are prerequisites.

Freshman, second semester, three hours per week.

Mine Surveying.—A course of lectures on underground surveying and shaft plumbing. The course also includes the solution of numerous surveying problems, requiring a thorough knowledge of mathematics. Exercises in platting and in preparing cross and longitudinal sections of underground workings; calculating quantities of material removed from the stopes, and of tonnage of blocked out ore bodies.

Sophomore, second semester, two hours per week.

Plane Surveying, Field Work.—A course of practical surveying in the field. During their stay in the field the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc. Determination of true meridian by solar observation and by observation on Polaris. Traverse survey with transit and steel tape, angles by repetition, azimuth and deflection. Problems in public land surveying in accordance with Manual of Instruction to United States Deputy Surveyors. Official survey of mining claims in application for United States patent; returns to consist of letter of transmittal, plat, field notes and computations, in form of transmission to United States Surveyor General. Topographic survey with transit and steel tape. Stadia and trigonometric survey. Base line and triangulation. Leveling for profile for contour lines and for establishment of bench marks. Staking out buildings and excavations for foundations and calculation of quantities to be excavated. Survey of ditch or flume line. Preliminary and location survey of railroad.

Freshman Summer Course, four weeks.

Mine Surveying, Field Work.—A course of practical mine surveying at a mine in actual operation. During their stay at the mine the students are required to execute the following surveys and prepare the necessary field notes, maps, profiles, calculation sheets, etc.; Establishment of a base line and determination of its true bearing by solar and polaris observation. Complete survey of the surface arrangement of a mine, showing all buildings and structures, shafts, adits, etc., with their relative elevations. Complete survey of the underground workings of a mine; including shafts, levels, raises, winzes and stopes. Plumbing a vertical shaft by various methods. Calculating latitudes and departures of underground surveys and preparing a survey record, showing station numbers, horizontal and vertical angles, slope and horizontal distances, true bearing, latitude and departure of all courses; the co-ordinates for each station north, south, east and west of an assumed initial point; also the elevation of each station above an assumed datum, calculated from the vertical angles and slope distances. Checking surveys by

platting and calculation, and adjusting allowable errors by approved methods.

Junior, first semester, first term, fifteen hours per week.

Topographical Drawing.—The work consists in platting on a convenient scale the surveys executed in the field by the Sophomores. During the preparation of the various topographical sheets, the students are instructed in the use of conventional signs for surface representations, including additional conventions required by the mining engineer, such as those for geological outcrops, stratification, mineral veins, shafts, tunnels, mine dumps, mills, etc. The students also receive directions in the construction of contour lines and in laying out railroads and wagon roads, dams, reservoirs, flumes, ditches, etc., on contour maps, and in calculating the quantities of cut and fill, the capacity of reservoirs, etc., by cross sections made from such contour maps. In this work special attention is given to lettering, titles, borders and north points, and general neatness in execution.

Sophomore, first semester, first term, nine hours per week.

MINING, ORE DRESSING AND ENGINEERING DESIGN

PROFESSOR SIMONS, ASSISTANT PROFESSOR ADAMS

Mining.—An outline of the geographical and geological distribution of the ores of the useful minerals. Prospecting, discovery, locating and acquiring title to mining claims. Breaking ground by the various methods of hand work, rotary and percussion drills. Explosives and their uses. Supporting excavations by timbering, masonry and metallic supports. The lectures and recitations are illustrated by drawings, prints, models and frequent visits to the local mines where mining operations are observed.

Junior, first and second semester, two hours per week.

Mining Laboratory Practice.—One afternoon a week is spent in studying air drills, besides making actual tests on various kinds of drills, such as air consumption, rate of drilling, efficiency tests and cost of operating. In addition to the above the students take trips underground to make a study of the practical side of mining. Special attention is given to the uses and handling of explosives, methods of timbering, stoping, diamond drilling and boring by percussion drills.

Juniors, second semester, second term, one afternoon per week.

Mining.—Exploitation of the useful minerals by open work, and the various methods of underground stoping. Mine haulage. Hoisting and hoisting machinery and accessories. Drainage and pumping. Air compression. Ventilation, nat-

ural and artificial. Lighting and sanitary arrangements. The study of mining operations on a commercial scale. The superintendence and management of mines. Selecting and buying supplies and machinery for mining operations. Mining economics and mine accounts. Examination and reporting on mines and mining enterprises.

*Senior, first semester, first term, two hours per week.
Senior, first semester, second term, three hours per week.*

Mining.—Prospecting for placer deposits. Exploitation of gold placers by various methods, including hydraulicking and dredging. Water supply for hydraulic and other mining operations. Reservoirs, dams, ditches and pipe lines.

Senior, second semester, three hours per week.

Ore Dressing.—Lectures and recitations. The object and general principles of ore dressing. Stamp milling, followed by amalgamation and concentration. Description of the construction and operation of the principle types of crushers, stamps, classifiers, concentrating tables and accessories. The lectures are amplified by frequent visits to local mills and ore dressing plants and by practical tests in the school laboratory.

Senior, first semester, second term, two hours per week.

Ore Dressing.—A study of the physical laws governing the various processes of ore dressing, the laws of crushing, of jigging, of free and hindered settling. The principles of screen sizing and hydraulic classification. Study of the construction and operation of typical milling machinery, rolls, grinding mills, jigs, tables, vanners, magnetic separators, flotation processes and mill accessories. Power transmission and water supply for milling operations. The study of design and methods of ore dressing at plants visited during the school year. Practical tests in the ore dressing department of the school laboratory.

The course of Mining and Ore Dressing is completed by a two weeks' excursion to districts where Mining and Ore Dressing methods can be studied which do not prevail in the Butte district.

Senior, second semester, two hours per week.

Mining Engineering Design.—In this work the students are taught to make designs of structures in woods, masonry, and metal, such as are required of the mining engineer. These designs include ore and coal bins, railroad trestles, head frames, and various buildings found at a mine, such as boiler, compressor, and warehouses, hoist house, and general

offices. The problems with all conditions and requirements are dictated to the students in the classroom. Numerous blue-prints obtained from actual structures are on file for reference.

Junior, first semester, second term, nine hours per week.

Junior, second semester, six hours per week.

Mining Engineering Design.—Leading up from the design of single structures this course consists in the design of a complete plant for one or more of the operations of mining and ore dressing. Besides the design and arrangement of a plant for the exploitation of the mine, each student also makes a design of a complete concentrating and stamp mill. It is the aim in this course to develop the originality of the student; although the professor in charge is always present to assist, the student is thrown upon his own resources as far as possible. He is required to make use of catalogue and reference books to obtain the data necessary for the completion of his problem. Attention is given to assembling, bills of materials, and the item of costs. The problems are given to the students and discussed in the classroom.

Senior, first semester, second term, and second semester, six hours per week.

MINING LAW.

JUDGE EDWARD B. HOWELL OF THE MONTANA BAR.

A course of instruction on the law relating to mining claims, including the method of acquiring title from the United States to lode, placer, tunnel and mill-site claims in the various states and Alaska, with a comparative study of federal and state laws on the subject, the law relating to extralateral rights, leases, options to purchase, conveyance of mining claims, and water rights, the relative rights of citizens and aliens in the tenure of mining claims. The object of the course is to give the student a good working knowledge of mining law, and to this end students are required to draft location notices and similar instruments that might become necessary in their work in the field. Through the recitations the class is given a thorough drill in rights of the locator, also in ways in which these rights may be transmitted or may be forfeited, all principles being abundantly illustrated by actual and hypothetical cases. Questions of more complexity are illustrated by elaborate models and charts, many of these models were constructed to represent the claims of mining companies in the courts.

The course in Mining Law consists of lectures and recitations covering a period of two months and is required of the Senior class. The class uses as a text book for this course Mr. Howell's manual on "Lode and Placer Claims."

EQUIPMENT

The equipment of the School of Mines has been secured through appropriations made by the Legislature of the State. The total sum invested for this purpose now amounts to nearly \$75,000, and represents a careful selection of the latest and best apparatus for the different departments of the School. The descriptions which follow concern the more important articles that have been procured to illustrate or to facilitate the work in the several departments.

DEPARTMENT OF MATHEMATICS.

The work in this department is to lay a solid foundation for a large part of the scientific discussions which are necessarily connected with all branches of the study of engineering. The department is furnished with large recitation and lecture rooms on the first floor, abundantly supplied with blackboard space, terrestrial and celestial globes, some simple models, and a blackboard ruled in squares for tracing the graphs of equations and of natural phenomena.

DEPARTMENT OF CHEMISTRY.

In this, as in all other departments where laboratory work is required, the demand for a large and varied equipment of apparatus and facilities for investigation is great, and the successful prosecution of the purpose for which the technical school is maintained is directly related to the perfection of this equipment. Nearly three-fourths of the entire first floor or basement of the School of Mines has been devoted to the use of this department, together with a lecture room on the second floor. In this space four laboratories have been fitted up, one for qual-

itative and quantitative analysis, one for metallurgy, and two special laboratories. To these have been added a balance room, a store room for laboratory supplies and a dispensary where the prepared tests for the students in the laboratories are kept.

The laboratories are furnished with working desks of the most approved pattern—each student having his own particular stand—where he is supplied with gas, water, blast, Bunsen burners, a rack for chemical reagents and a cupboard with lock and key so that he can keep securely the apparatus and material assigned for his use. The laboratories are also supplied with hoods in which are to be found hot plates, air baths, steam evaporating pans, hydrogen-sulphide apparatus and a flue with a strong draft to draw off the noxious vapors. The laboratories for qualitative and quantitative analysis and for metallurgy are sufficient for the accommodation of 48 students each.

The students' balance room is provided with six analytical balances for the use of the student in the laboratories. These balances are placed on piers disconnected from the walls and floors of the building so that the vibration is reduced to a minimum.

The special laboratories and preparation rooms are equipped with modern conveniences for carrying on analytical and metallurgical work. In these rooms all the chemical reagents are prepared for the use of the student in the laboratories and all check analysis on the students' work is made. Two dark rooms are provided for photographic work, spectrum analysis, making blue prints and lantern slides.

The chemical lecture room, located on the second floor, is provided with a demonstrating table, furnished with pneumatic trough, gas, water, hydrogen and oxygen blast

and direct and alternating currents of electricity up to 750 volts and 45 amperes. The demonstrating table is backed with a hood furnished with the same appurtenances as are provided for the hoods in the laboratories.

DEPARTMENT OF METALLURGY.

The assay laboratory is situated on the first or basement floor of the building, and is equipped with six of the latest model coal assay furnaces. There are also two gas assay furnaces and one gasoline furnace, which can be used for special work, and a gas retort and melting furnace for melting bullion, making alloys, retorting amalgam, casting copper and other anodes, etc.

The pulp room adjoins the assay laboratory, where all charges are weighed and fluxed. Convenient cupboards are provided for storing samples. The silver and gold balances are located in the same room as the analytical balances, and are of the latest approved design.

The crusher room is provided with a Gates crusher, a Low crusher, an Englebach grinder, capable of grinding pulp to 80 mesh, a Braun planetary pulverizer, a buckingboard, tables upon which to roll samples, and a series of drawers capable of holding 454 twenty-five-pound pulp samples. The supply of assay samples consists of a large number of copper, lead, gold and silver ores, together with mattes, both copper and lead, slag, flue-dust, calcines, concentrates, tailings, and all smelter products from the copper and lead smelters and other plants of the state.

In the assay laboratory are located separate cyanide outfits for testing ore by the cyanide process. There is also located in this laboratory, a calcining furnace capable of being used as a reverberatory or muffle roasting furnace, where large lots can be calcined, or a chlorination roast can be made for hyposulphite treatment.

There are arrangements for treating free milling gold ores by the amalgamation process, as well as cyaniding the tailings from this process.

Gas analysis is at present carried on in the chemical lecture room. There is a very complete set of Hempel's gas apparatus, and analyses are made of gasses of combustion, reverberatory and blast furnace, illuminating gases, etc.

A dark room for students' use adjoins the balance room, which contains a large Kirchoff-Bunsen spectroscope and supplementary apparatus for qualitative analytical work in determining the presence of the alkali and alkaline earth metals by their volatilization in the non-luminous flame of the Bunsen burner. The spectroscope is provided with a scale for the determination of the exact location and relative position of the lines of the spectra, or, two spectra may be studied and compared at the same time.

MINING, ORE DRESSING, AND METALLURGY.

A room 24 by 31 feet is provided on the second floor for lectures in the various branches of mining and ore-dressing. The drawing classes occupy three large, well-lighted rooms. Ample table-room and individual drawer room are provided throughout; cabinets for filing drawings and drawing-boards are also provided. A large collection of drawings furnished by various manufacturing companies of mining machinery is on hand and is used as an aid to the student in developing new work. The collection of parts of machines is gradually increasing. This material is of great assistance to the department in developing the work in machine design.

For the practical work in surveying the following in-

struments have been provided: Ten engineering transits; one from Buff and Buff, two from C. L. Berger & Sons, four from Gurley, one from Keuffel and Esser, one from Young and Son, and one from Eugene Dietzgen. Five levels—one from Buff, one from Gurley, two from Keuffel & Esser, one from Berger, and one from Young & Son. One solar compass and one sextant with artificial horizon, from Gurley; two aneroids by Short & Mason (London), and a collection of minor apparatus, including Brunton compass, clinometers, Locke levels, chains, tapes, plumets, shaft plumbing equipment, rods and flags, necessary in carrying on the work of the department. To this equipment has recently been added by donation a plane table with alidade, a Breithaupt and Sons' level with tripod, and a Tacher's calculating instrument.

A mine model has been constructed in the school shops for use in the lecture room, which greatly facilitates the solving of many of the more complicated problems in mine surveying.

The metallurgical laboratory, which has recently been completed, occupies a building by itself. This building also contains the central heating plant and the engine and dynamo room. The metallurgical laboratory proper occupies a room 77 by 70 feet, half of which is devoted to ore dressing. The ore dressing department consists of a set of storage bins with a capacity of from 80 to 100 tons of ore. One eight-inch by twelve-inch Dodge crusher, two sets of twelve and one-half-inch by twelve-inch rolls, two belt elevators, three trommels thirty inches in diameter and forty-eight inches long, one impact screen for dry screening, a duplex Callow screen for screening to forty and eighty mesh, three Evans and one Hartz jig, one Huntington mill, one Wilfley table, one four-foot Frue Vanner and a Dings magnetic separator. There is also a three-stamp mill with amalgamating table. Accessories consist of classifiers, settling tanks, centrifugal sand and water pumps, etc.

An equipment for making cyaniding tests provides for leaching ores in five-ton lots. In this plant sands and slimes may be separated, dewatered and treated separately. There are five vats and two sump tanks, one steel tank provided with air and mechanical agitators. All necessary filters, zinc boxes, etc., for making commercial tests are installed for use in this plant.

A pan amalgamation plant consists of a Bruckner chloridizing furnace, a pan amalgamator and settling tank. All the usual equipment, such as steam, launders and utensils, etc., are at hand for the convenient working of this plant.

The laboratory contains a Wedge furnace designed to be used as a reverbatory or a muffler furnace. This furnace is mechanically rabbled and used in roasting ores in lots of one ton or more. There is also a lead-lined agitation barrel provided for experiments involving this type of apparatus.

The mill is arranged in such a manner that complete tests on a commercial scale can be made on various kinds of ore by shifting the travel of the ore over such machines as are found to be best suited to treat any particular ore.

The laboratory also contains a miniature testing plant consisting of small sized jigs. Wilfley table, hydraulic classifiers, automatic feeder, etc., for testing ore in quantities up to four pounds, preliminary to sending the ore through the large mill.

The museum of the school contains a very complete collection of the products from the ore dressing plants at the Butte, Anaconda and Great Falls smelters. These samples are extensively used in lectures on ore dressing, as they show in a most excellent manner the mechanical changes which a particle of ore undergoes during its

travel through the various machines, designed to separate the valuable metal from its gangue.

On the tables of the library may be found all the leading American technical magazines as well as many foreign publications. The library also contains a valuable collection of text books on all the subjects of civil and mining engineering, the use of which is open to all students upon application to the librarian. The office of the Professor of Mining and Ore Dressing also contains a large collection of catalogues, blue prints, and bulletins from leading manufacturers of mining, milling and smelting machinery. The school is indebted to these manufacturers for the supply of such catalogues and for the many extra copies which they have kindly furnished for distribution among the students.

Several mine maps, an ideal section of a Butte copper vein, a very attractive section through part of the Boston & Montana concentrator at Great Falls, and a great number of appropriate photographs and drawings decorate the walls of the museum and library; these include views of Montana mining towns, the Washoe smelter at Anaconda, of the Boston & Montana smelter at Great Falls and of various mines and mills about the State. There is a large drawing to illustrate the method of sampling in use at the Taylor & Brunton Sampling Works (now the Washoe Sampling Works) at Butte, and also several drawings of coal washery of the Cottonwood Coal Company. Finally there are several diagrams, illustrating the relative production of copper, silver and gold in Montana and other states.

The various mine models, donated from time to time by leading mining companies of Butte, are exceedingly useful in demonstrating not only the geological features indicated on such models, but also the various phases and

methods of shaft sinking, drifting, cross-cutting and stoping, practiced in the mines represented by said models.

DEPARTMENT OF GEOLOGY AND MINERALOGY.

The department of geology and mineralogy occupies five rooms and part of four others. On the second floor are the office, the lecture room, and the mineralogical laboratory, with provision in the library for certain maps; and on the third floor are the museums, the petrographic laboratory, dark room and storage rooms.

The collection of minerals belonging to the department have been subjected to a two-fold division into museum specimens and student specimens. The student hand-specimens are placed in drawers where they are accessible at all times; the material for laboratory work is kept in a separate cabinet; and the museum collections, which consist of the rarer, larger and more delicate specimens, are kept under glass.

Of general usefulness in all courses of the department are the storage room, the dark room, the lecture room and the office. The office is a capacious room fitted with desks and tables for the convenience of officers of the department, with cabinets for various collections and with bookcases for the departmental library. The lecture room is provided with wall maps, blackboards and suitable desks and chairs. It is thirty-one feet long by twenty-four feet wide. One corner of the room is occupied by a geological relief map of the United States modeled on a section of a globe sixteen feet in diameter. This shows the topography as well as the areal geology of the entire country. A map-case five feet square contains the larger geological and areal maps. The dark room on the third floor contains apparatus and chemicals

for photographic work. The storage room on the same floor contains materials for exchange, etc.

Mineralogy and Geology.—An extensive collection of crystals is used not only to illustrate the lectures in crystallography but also as material for laboratory exercise. In addition to these real crystals, four series of crystal models are available, two of wood, one of celluloid and one of glass. A reflection goniometer for the accurate measurement of crystal angles is installed in the dark room, while hand goniometers for laboratory work are kept in a case in the mineralogical laboratory.

The main museum occupies the north wing of the third floor of the building in a room thirty feet by sixty feet. Twenty-four large glass cases are devoted to the mineral collections and fourteen additional cases are devoted to ores, rocks, non-metallic products, specimens illustrating geological structures and some of the larger fossils. Five cases are devoted to a special collection of minerals from the Butte district. All mineral collections are arranged according to the Dana classifications. A collection of one hundred and sixty gold crystals is kept in one of the cases. The mineral collections in the museum contain more than three thousand specimens. The systematic rock collection contain over fifteen hundred specimens. The museum in all contains over ten thousand specimens.

The mine model museum occupies a room thirty feet square in the southwest wing of the third floor of the building. Here are to be found many of the classic mine models used in the protracted mining litigation for which the Butte camp has been noted. These models are of many designs and styles and are of much practical use in illustrating the principles and facts of mining geology.

The mineralogical laboratory is thirty-one feet square and contains six laboratory tables capable of accommo-

dating thirty-six students. Each student is provided with complete apparatus for the rapid determination of minerals by physical and chemical tests. A case in one corner of the laboratory contains the students' reference collection, containing over 300 mineral specimens and varieties, arranged according to Dana. Pycnometers, Westphal balances, Plattner scales, burettes and miscellaneous laboratory supplies are at hand in another case. A collection of minerals for laboratory determination by the students is kept in a set of drawers in the office. Here also will be found a case of chemical and mineralogical reagents and appliances, a tile-topped table, a hood and all the apparatus necessary for conducting qualitative and quantitative analysis of minerals and rocks. A Greenough-Leitz binocular microscope is available for the mineralogy laboratory.

The working paleontological collection consists of over two thousand catalogued fossils, systematically arranged in cases in the Museum.

For the work in field geology, the department is equipped with Brunton compasses, clinometers, levels, aneroid barometers, tapes, cameras, field glasses and a complete camp outfit.

Petrography—In the geological museum is a case containing seventeen petrographic microscopes. Ten of these are of the French type, made by Nacet in Paris; and seven of the German type, made by Leitz at Wetzlar. These microscopes are all provided with the necessary attachments for petrographic work, and the two of them, one Leitz and one Nacet, are of a larger size than the others, and are equipped with accessories for research work. The School owns a fine projection apparatus which is provided with a large petrographic microscope for use in illustrating lectures in petrography.

A specially constructed cabinet in one corner of the

museum contains five hundred slides of minerals, six hundred thin sections of rocks, and one hundred slides of economic interest. The collection of mineral sections is supplemented by eight additional sets of fifteen more important mineral slides put up in individual boxes and a box containing seventeen slides especially prepared for use with the projection microscope.

The thin sections of rocks are nearly all represented by hand specimens in the museum collections already described, so that the student may observe the macroscopic character along with his microscopic work. A set of one hundred and four wooden models of crystals of the more important rock-forming minerals is also contained in the thin-section cabinet; while a collection of twenty glass models of rock-forming minerals after Grubenmann occupies a wall case.

The thin-section lathe room contains complete equipment for making thin sections of rocks and minerals, and for polishing opaque minerals. There are two electrically driven lathes in this room; one is provided with two laps for rough and fine grinding respectively; the other with a diamond wheel for cutting slides, and with two emery wheels for grinding. Emery, Canada balsam, thick glass, slides, covers and all other supplies and accessories are at hand for use.

A camera for taking photo-micrographs is installed in the dark room.

DEPARTMENT OF MECHANICS.

This department occupies three rooms on the first floor. The lecture room has a seating capacity of forty persons, and is provided with modern lecture room conveniences, such as water, gas, electric current, etc. The lecture apparatus consists of a select equipment for illustrating

the laws of mechanics, electricity, sound and light. The physical laboratory is equipped with heavy tables and apparatus for the measurement of physical constants. The apparatus consists of the usual assortment required in the measurement of density, elasticity, force of gravity, the latent heats of fusion and evaporation, the mechanical equivalent of heat, etc. There is also a good photometer, together with the necessary accessories. For the measurements in electricity, there are provided ammeters, voltmeters, resistance boxes, Wheatstone bridges, galvanometers, batteries, keys, etc.

An engine and dynamo laboratory is located in the basement of the building; there is installed here a gas engine of ten horsepower for experimental purposes. A ten horsepower three phase induction motor drives direct and alternating current dynamos. A switchboard connects these machines with lines running to various parts of the building, also to motors and a rotary converter, and to a bank of transformers. It is possible to illustrate most of the connections in power transmission systems with the apparatus at hand as well as to perform many interesting tests. A storage battery of ten cells is also connected to the switchboard so that any number of them may be connected to any of the circuits for lecture or experimental purposes. It is charged from the direct current dynamo or mercury arc rectifier. The requisite voltmeters and ammeters for both alternating and direct currents, rheostats, etc., are provided. The laboratory is also supplied with galvanometers, standard condensers, resistance boxes, etc., necessary for the more exact and complicated electrical measurements.

The power plant for the mill contains two 80 horsepower boilers, a 75 horsepower high speed engine belted to a 50 K. W., three-phase generator with switchboard and necessary instruments, and an air compressor with

steam cylinders 8-inch by 10-inch and air cylinders $7\frac{1}{2}$ -inch and 13-inch by 10-inch.

In connection with this laboratory there is a small shop equipped with the following metal working machines: One thirteen-inch screw cutting lathe; one sixteen-inch shaper; one twenty-two-inch drill. The tool cabinets are provided with a good equipment of bench tools for both metal and wood work. There is also a small blacksmith shop used for making and repairing tools and for giving such students as may desire it, practice in forge work in iron and steel.

In addition to the material mentioned above the testing laboratory has at its disposal a 100,000-pound Olson machine arranged for tensile, compression, and shearing tests. The accessories consist of the following: One compression micrometer especially designed for measuring the compression of stone cubes and other building material; one improved deflection instrument for measuring the deflection of beams subject to load; one Henning's improved micrometer instrument for measuring the compression or elongation of long specimens. The laboratory is also equipped with a cement testing outfit from Fairbanks Morse & Co. All accessories, such as molds, sieves, etc., are at hand for making a thorough study of this important subject. The apparatus for making a complete indicator and brake test of an engine are provided, also the apparatus for making a study of the heating power of coals.

THE LIBRARY

CHARLOTTE RUSSELL, LIBRARIAN.

The library is located on the second floor of the main building, its windows facing the main range of the Rocky Mountains and overlooking the famous Anaconda Hill. It is a large, well-lighted room and offers with its alcoves a convenient and quiet place for students' study and leisure hours.

The number of publications in the library, departmental and others is nearly 9,000. As a United States Depository for Public Documents, the shelves contain the issues of the United States Geological, Coast, and Geodetic Surveys; Reports on Forestry, Forest Reserves, and Irrigation; of the Naval Observatories; Engineering Corps, and Bureau of Mines. Besides these the library receives the official scientific reports of various state surveys, and of Mexico, Canada, Great Britain, France, Norway, Cape of Good Hope, New Zealand, and the states of Australia. In addition to this abundance of technical and scientific literature all the more important standard reference works are procured as they are published.

The leading scientific, mining engineering, geological and literary magazines are to be found on the library tables, and as fast as the several volumes of these are completed they are bound and thus furnish in permanent form, more or less complete discussions of the latest and most important advances that have been made in their several departments. To these are added the bound volumes of the proceedings of the great scientific societies, such as the Geological Society of America, the American Chemical Society, and the American Institute of Mining Engineers, and periodical issues of other colleges.

LIST OF STUDENTS

SENIOR CLASS.

Curran, Francis R.	Butte, Montana
Hill, William J.	South Bend, Indiana
Hogan, Eugene	Butte, Montana
Lind, A. Leslie	Butte, Montana
Lyon, Thomas T., Jr.	Butte, Montana
Mason, Veyne V.	Helena, Montana
Steele, Chester H.	Butte, Montana
Strang, Willis B.	Musselshell, Montana
Wong, S. A.	Honolulu, H. I.

JUNIOR CLASS.

Cannon, Frank D.	Gibbonsville, Idaho
Carlisle, Stanley B.	Winfield, Kansas
Cheung, T. C.	Hong Kong, China
Collins, Thomas F.	Butte, Montana
Driscoll, Thomas J.	Butte, Montana
Freshman, Herman B.	Butte, Montana
Gabisch, Francis	Helena, Montana
Gaethke, Fred P.	Butte, Montana
Lee, L. P.	Hong Kong, China
Ling, Tao	Honan, China
Neelon, Francis A.	Minneapolis, Minn.
Norton, John E.	Butte, Montana
Papa, J. M. A.	Butte, Montana
Parker, Howard	Butte, Montana
Sparks, Karl T.	Butte, Montana
Spiegel, Sam	Butte, Montana
Vivian, George F.	Butte, Montana
Wilkinson, Thomas	Butte, Montana

SOPHOMORE CLASS.

Achuck, Warren W.	Honolulu, Hawaii
Barry, John	Butte, Montana
Beyer, Daniel C.	Long Island City, N. Y.
Cliff, Frank M.	Butte, Montana
Ellingwood, C. W., Jr.	Butte, Montana
Foran, Edwin V.	Seattle, Washington
Hunt, Peter F.	Butte, Montana
Loughran, David E.	Butte, Montana
Makinson, Roy	Butte, Montana
Mannick, Alfred	Butte, Montana

McAuliffe, Charles, Jr.	Butte, Montana
Nelson, S. A.	Larson, Sweden
O'Donnell, Neil	Butte, Montana
Petriz, William E.	Rockford, Illinois
Pierce, Wilbur C.	Arthur, Nevada
Thrasher, Willard	Butte, Montana
Vaupell, C. W.	Lewistown, Montana
Whealdon, Alfred N.	The Dalles, Oregon

FRESHMAN CLASS.

Aaronson, William A.	Philadelphia, Pa.
Amer, W. Raymond	Anaconda, Montana
Anderson, Ernest	Anaconda, Montana
Bartzen, Clarence	Butte, Montana
Clifford, James	Butte, Montana
Clinch, Vernon	Butte, Montana
Clucas, Lewis M.	Anaconda, Montana
Courtney, Edward	Butte, Montana
Engel, Abe	Butte, Montana
Freshman, Walter C.	Butte, Montana
Fredell, Clarence	Anaconda, Montana
Guernsey, Elmon B.	Portland, Oregon
Heatherly, Sam	Red Lodge, Montana
Kent, A. T.	Butte, Montana
Lightfoot, James E.	Soldier, Idaho
Milwick, Clifford F.	Anaconda, Montana
Newton, Claude	Butte, Montana
Peterson, John N.	Terraville, S. D.
Rowe, Sidney	Butte, Montana
Ryburn, Robert M.	Granbury, Texas
Symons, Henry H.	Butte, Montana
Werelius, Walter	Butte, Montana

SPECIAL STUDENTS.

Conness, George S.	Butte, Montana
Cummons, Hershel M.	Melba, Idaho
Dunn, Daniel E.	New York, N. Y.
Harper, Hugh H.	Spring Valley, Ohio
Hoss, Fred M.	Helena, Montana
Sennett, Florence	Butte, Montana
Taylor, Nicholas	Sheridan, Montana
Tiffany, W. C.	Seattle, Washington

REGISTER OF ALUMNI

- Adami, Arthur E., 1907.....Butte, Montana
Asst. Professor of Mining Engineering, Mont. State School of Mines.
- Aline, Peter A., 1915.....Great Falls, Montana
Asst. Chemist, B. & M. Reduction Dep't, A. C. M. Co.
- Andrew, John T., 1912.....Butte, Montana
- Archibald, George B., 1905.....Salt Lake City, Utah
Carey Act and Mineral Inspector, U. S. General Land Office.
- Balmford, Alfred, 1904 Warren, Arizona
- Bassett, Arthur F., 1912.....Humboldt, Arizona
Asst. Mill Supt. Consolidated Arizona Smelting Co.
- Bender, Louis V., 1903.....Anaconda, Montana
Superintendent Washoe Reduction Works, A. C. M. Co.
- Bovett, C. A., 1907.....Mason, Nevada
Mining Engineer, Western Nevada Mine, Nevada-Douglas Cons. Mining Co.
- Bowden, Malcolm, 1908 Helena, Montana
- Brinton, Owen F., 1905.....
Namtu, Northern Shan States, Burma, India
Burma Mines Ltd.
- Brulo, William, 1909 Helena, Montana
State Land Examiner for Montana.
- Christian, Otto B., 1912 Butte, Montana
Surveyor A. C. M. Company.
- Clinch, R. S., 1911 Nacozzari, Sonora, Mexico
Firm of Smith & Clinch Contractors, working Promontario Mine.
- Clinch, W. D., 1912 Butte, Montana
Metallurgical Assistant, Timber Butte Milling Company.
- Cohan, Jesse, 1912 Butte, Montana
*Mining Engineer, Timber Butte Milling Company.
 Consulting Engineer, Butte-Great Falls Mining Company.*
- Cole, Robert J., 1914 Butte, Montana
Engineering Dep't., A. C. M. Co.
- Cooke, Hamilton, Jr., 1912.....St. Louis, Missouri
New York Life Insurance Company.
- Corey, C. R., 1905 Seattle, Washington
Asst. Prof. of Metallurgy, College of Mines, University of Washington.
- Crittenden, Zar T., 1913.....La Pas, Manitoba, Canada
Cullity & Crittenden, Mining Engineers.
- Cullity, Emmet R., 1912.....La Pas, Manitoba, Canada
Cullity & Crittenden, Mining Engineers.
- Dobson, Chris G., 1913 Butte, Montana
Assistant Engineer, Original Mine, A. C. M. Co.
- Dugan, J. F., 1906 Butte, Montana
Assistant Foreman, Never Sweat Mine, A. C. M. Co.
- Duling, J. Fred, 1904 Los Angeles, California
General Engineering Practice.

- Duthie, John M., 1905 Libby, Montana
Private Practice, Mining & Civil Engineering.
- Elford, Basil E., 1905 Anaconda, Montana
Chemical Laboratory, Washoe Smelter, A. C. M. Co.
- Ellis, Willis H., 1908 Butte, Montana
Field Assistant to Commissioner of Public Works to City of Butte.
- Evans, James R., 1909
 Tshikapa, Congo Belge, West Africa, via Boma-Luibo
Formaniere Mission Kasai.
- Feeney, Charles W., 1906 Butte, Montana
County Surveyor, Silver Bow County.
- Foote, Frank A., 1908 Delta, Utah
Farmer.
- Fowler, George M., 1912 Butte, Montana
Assistant Geologist, A. C. M. Co.
- Gidel, Murl H., 1912 Butte, Montana
Assistant Geologist, A. C. M. Co.
- Gieser, Herbert S., 1906 Anaconda, Montana
Concentrating Dep't. Washoe Smelter, A. C. M. Co.
- Gilham, Ralph, 1909 Townsend, Montana
- Giovanetti, Ettore, 1912 Butte, Montana
Instructor Butte Business College.
- Goodell, Luther T., 1915 Butte, Montana
Sampler Speculator Mine, A. C. M. Co.
- Grunert, August, 1910 Butte, Montana
Assayer, A. C. M. Co.
- Haines, Peter A., 1909 Rivermines, Missouri
Superintendent Doe Run Lead Co.
- Hanson, Wilbur W., 1913 Butte, Montana
Mining Engineer, A. C. M. Co.
- Hunt, John E., 1915 Butte, Montana
Testing Dep't., Timber Butte Milling Co.
- Ireland, Arthur J., 1904.
Deceased.
- Jensen, Walter H., 1910 Great Falls, Montana
With Montana Brewing Company
- Johns, John W., 1906 Marysville, Montana
Foreman Gloster Mine, Barnes-King Development Co.
- Johnstone, J. Clark, 1909 Butte, Montana
Testing Dep't., Timber Butte Milling Co.
- Kane, Edward G., 1909 Butte, Montana
Assistant Foreman Bell Mine, A. C. M. Co.
- Kane, L. M., 1906 Butte, Montana
- Ketcham, S. H., 1908 Missoula, Montana
Private Practice, Engineering Office.
- Kirby, Kenneth P., 1909 Butte, Montana
Mining Engineer, A. C. M. Co.

- Kuphal, Henry E., 1904 Wallace, Idaho
Consulting Mining Engineer.
- Lomas, E. Percy, 1908 Butte, Montana
Sampler Speculator Mine, North Butte Mining Co.
- Loughran, Michael, 1909 Butte, Montana
Mining Engineer, A. C. M. Co.
- Lowry, J. M., Jr., 1908 Butte, Montana
Engineer, Montana Power Co.
- Lyden, Joseph P., 1914 Butte, Montana
Assistant Geologist, A. C. M. Co.
- McCool, Edward J., 1913 Butte, Montana
Mining Engineer, A. C. M. Co.
- McCracken, R. H., 1907 Cerro de Pasco, Peru
Cerro de Pasco Mining Co. Ltd.
- McElvenny, L. T., 1911 Butte, Montana
- McGee, John, 1904 Tonopah, Nevada
General Manager Greenwater Copper Mines; Great Western Cons. Mng. Co., and Tonopah Bonanza Mining Co.
- McLaughlin, William D., 1908.....Butte, Montana
Surveyor, Tramway Mine, A. C. M. Co.
- McMahon, Brandon, 1914 Butte, Montana
Sampler, Mountain View Mine, A. C. M. Co.
- Mackel, Louis C., 1905 Whitehall, Montana
Farmer.
- MacPherson, Frank H., 1914 Butte, Montana
Mining Engineer, A. C. M. Co.
- MacRae, Lachlan D., 1904 Nacozari, Sonora, Mexico
- Malloy, Emmet E., 1909 Butte, Montana
Deputy State Land Agent for Montana.
- Manwaring, Joseph H., 1913 Butte, Montana
Superintendent, Butte-Ballaklava Copper Co.
- Meiklejohn, Archie B., 1908 Los Angeles, California
Distribution Accountant, Southern California Edison Co.
- Murphy, Joseph G., 1914 Butte, Montana
Geologist, Butte & Superior Copper Co.
- Murphy, James K., 1911 Anaconda, Montana
Superintendent of Roasting Plant, Washoe Smelter, A. C. M. Co.
- Newton, Lucian, 1913 Bearmouth, Montana
General Manager Northwestern Mining Co.
- O'Brien, Albert, 1908 Butte, Montana
Mining Engineer, Barker & Wilson.
- O'Connor, C. H., 1911 Butte, Montana
Mining Engineering, Butte-Ballaklava Copper Co.
- Patten, Earle B., 1908 Philipsburg, Montana
*Mining Engineer.
County Surveyor Granite County.*
- Pauly, P. L., 1904 Butte, Montana
Draftsman, Timber Butte Milling Co.

- Peter, Ira B., 1909 Butte, Montana
Assistant City Engineer.
- Peterson, P. E., 1911 Jefferson Island, Montana
Superintendent, Iowa-Montana Development Co.
- Pierse, Edwin A., 1913 Great Falls, Montana
Assistant Chemist, A. C. M. Co.
- Pilger, Theodore F., 1912 Butte, Montana
Roach & Pilger, Real Estate, Mines, Loans and Investments.
- Pratt, A. F., 1913 Portland, Oregon
- Pratt, Paul D., 1905 Libby, Montana
Mining and Civil Engineering, Custom Work.
- Proctor, M. D., 1908 Truly, Montana
McNair & Proctor Ranch Company.
- Proctor, I. O., 1908 Butte, Montana
Metallurgical Engineer, Timber Butte Milling Co.
- Reardon, D. J., 1907 Butte, Montana
- Reber, Bert A., 1915 Butte, Montana
Leasing.
- Reese, Clark Clark, 1904 Long Beach, California
- Reid, Milton A., 1913 Anaconda, Montana
Chemist, Washoe Reduction Works.
- Roach, James, 1911.
Deceased.
- Schaefer, W. A., 1907.
Deceased.
- Schiffner, Otto B., 1908 Tonopah, Nevada
Mine Foreman, Great Western Consolidated Mining Co.
- Sheedy, John W., 1915 Butte, Montana
Millman, Butte & Superior Copper Co., Ltd.
- Shields, E. Floyd, 1911 Butte, Montana
Mining Engineer, Butte & Superior Copper Co., Ltd.
- Stevenson, Isabel Little, 1904 Newburg, West Virginia
- Stevenson, L. C. Newburg, West Virginia
Superintendent, Virginia-Maryland Coal Corporation.
- Stockett, Norman A., 1909 Paragon, Idaho
Superintendent Paragon Consolidated Mining Co.
- Stuewe, William J., 1910 Gold Hill, Oregon
Mine Owner and Operator.
- Sultzzer, H. Duke, 1911 Butte, Montana
Assistant Engineer A. C. M. Co.
- Tallant, Harry S., 1904 Palma Sola, Florida
Farmer.
- Ternouth, Blaine, 1914 Butte, Montana
Electrician, A. C. M. Co.
- Tout, Charles, 1911 Butte, Montana
Mill Foreman, Northwestern Mining Co.
- VanGundy, J. E., 1905 Kellogg, Idaho
Chief Engineer, Stewart Mining Co.

- Villars, Jesse R., 1908 Great Falls, Montana
Civil and Mining Engineer, General Practice.
- Walton, Lee M., 1908 Salt Lake City, Utah
Engineer.
- Warfield, Hershel, 1906 Los Angeles, California
Stocks and Bonds.
- Watson, Robert A., 1915.
Deceased.
- Wiegenstein, Henry J., 1909 Butte, Montana
Mining Engineer.
- Williams, Paul, 1912 Butte, Montana
Engineer, North Butte Mining Co.
- Wilson, Bert T., 1906 Goldendale, Washington
*Goldendale Machine Shop and Garage.
 Consulting Engineer.*
- Woodworth, Guy T., 1915 Great Falls, Montana
Mining Engineer.
- Wren, A. A. 1908
- Young, A. B., 1906 Canille, Arizona
Private Practice, Mining Engineer.
- Young, S. A., 1906 Astoria, Oregon
- Young, William A., 1909 Maiden, Montana
Lessee Maginnis Mine.
- Zentner, Arthur A. Anaconda, Montana
Superintendent Zinc Roasting Plant, Washoe Smelter, A. C. M. Co.

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